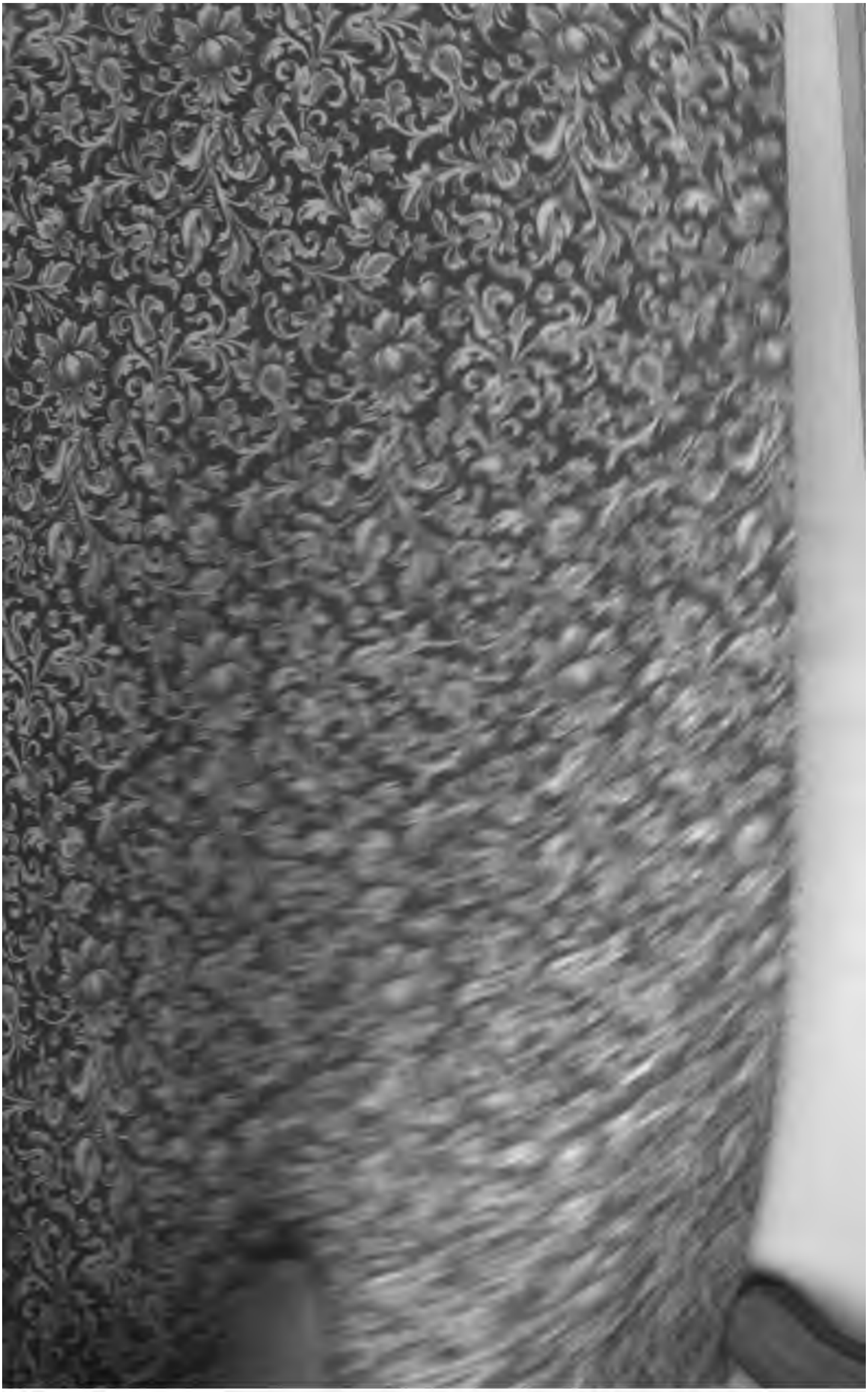

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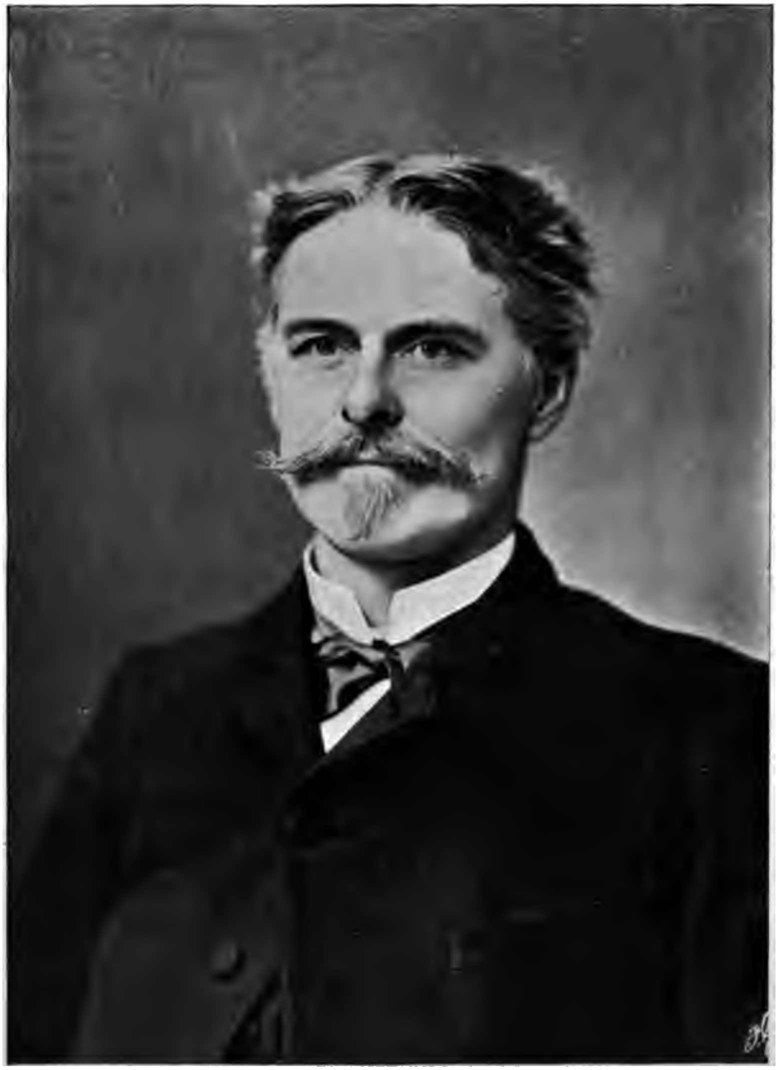

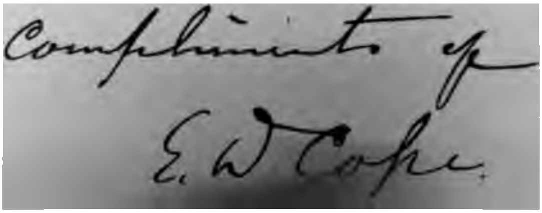
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EDWARD DRINKER COPE.

By HELEN DEAN KING, Bryn Mawr, Pa.

(Plate I.)

In the death of professor E. D. Cope which occurred at Philadelphia, on April 12th, 1897, science has lost a master in vertebrate paleontology and a brilliant explorer in the fields of zoology and philosophy. No man since Louis Agassiz has had so great an influence on the development and progress of biology in America; and his premature death at the age of fifty-seven has left unfinished investigations which would, if completed, greatly enrich our knowledge of the extinct fauna of the country and its relations to the more recent forms.

Edward Drinker Cope was born in Philadelphia, July 28th, 1840. His father, Alfred Cope, was a man of wealth and culture, possessing a considerable knowledge of botany and zoology. He early recognized and fostered in his son the strong love for nature which soon grew into an overpowering passion. To his father's help and guidance the lad owed much of his early scientific training, and it does not appear that he received any instruction in science while attending school. When not at his studies, young Cope spent most of his time in the woods and fields near his home. He was especially interested in reptiles, and his collection of salamanders, snakes and tortoises was not only carefully and skillfully prepared, but also fully identified by comparison with specimens in the museum of the Academy of Natural Sciences in Philadelphia.

Cope's school education was mostly carried on in the Westtown Academy, an institution near Philadelphia, under the

direction of Friends. He also studied for several years with a private tutor, Dr. Joseph Thomas, under whose instruction his natural aptitude in the use of language developed into that remarkable power of lucid and fluent expression for which he was later noted.

In 1859, having determined to be a naturalist, Cope went to Washington where he studied reptiles in the Smithsonian Institute under Spencer F. Baird. This same year his first contribution to scientific literature, "On the Primary Divisions of the Salamandridæ with a Description of Two New Species," (3),* appeared in the Proceedings of the Academy of Natural Sciences.

Returning to Philadelphia after a few months, Cope received his only collegiate training—a year at the University of Pennsylvania. During this time, and for the succeeding two years, he worked constantly in the Academy of Natural Sciences, cataloguing the serpents in the museum, describing new species and writing monographs on the different genera of reptiles and amphibians. As a result of these labors, he became, at the age of twenty-two, one of the leading herpetologists of the country.

In 1863-'64, Cope spent several months abroad where he visited the great museums in England, France, Holland, Austria and Prussia, and broadened his views as a comparative anatomist. On his return, he accepted a professorship of Comparative Zoology and Botany at Haverford College. In 1865, he married Miss Annie Pim, daughter of Richard Pim of Chester county, Pennsylvania. Owing to ill-health, professor Cope resigned his position at Haverford in 1867, and for the next twenty-two years he devoted himself entirely to exploration and research.

Professor Cope took up the study of the extinct Reptilia found in the green sands of New Jersey in 1866. This was his introduction into the field of vertebrate paleontology, in which, until his death, he was considered by many as foremost in America, if not in the world. From the Dinosaurs of New Jersey, he turned his attention to the Miocene fauna of Maryland and Virginia, and in 1868, began his investigations on

*Numbers in brackets refer to corresponding numbers in the accompanying bibliography.

the air-breathing vertebrates of the Ohio region. In the same year he published his first complete synopsis of the extinct Amphibia of North America, (56).

During the years 1871-'73, Cope joined many exploring expeditions to Kansas, Wyoming and Colorado. He was then appointed vertebrate paleontologist of the United States Geological and Geographical Survey of the Territories, and during his connection with this survey he explored and collected in every state and territory west of the Missouri. As a result of his own labors and those of special parties sent out at his own expense, Cope amassed a collection of vertebrate fossils from the west unequalled, perhaps, in number and variety of forms. His work on the survey was published by the government in several volumes: "The Vertebrata of the Cretaceous Formations of the West," (186); "Report Upon the Extinct Vertebrata obtained in New Mexico by Parties of the Expedition of 1874," (223); and "The Vertebrata of the Tertiary Formations of the West," (407). In recognition of the first two works, Cope was awarded in 1879, the Bigsby medal of the Geological Society of London. The University of Heidelberg still further rewarded his genius by conferring upon him, in 1886, the degree of Doctor of Philosophy—the highest honor in its power to bestow.

The loss of a greater part of his private fortune led Cope, in 1889, to accept the position of "Professor of Geology and Mineralogy" in the University of Pennsylvania. In 1895, he was transferred to the professorship of Zoology and Comparative Anatomy, the position he held at the time of his death.

In February 1897, professor Cope's health became seriously impaired, but he could not be induced to give up his work. The last few days of his life he grew worse very rapidly and it was considered unwise to remove him from his study and museum in Pine street, Philadelphia, where he was stricken down, to his home at Haverford. Thus he passed away surrounded by the objects to the study of which he had devoted his life. In his will, all his priceless collection of fossils was bequeathed to the University of Pennsylvania and to the Academy of Natural Sciences, and it is hoped that a worthy successor will finish the work of classification and description which professor Cope did not live to complete.

In 1878, Cope became associate editor of the "American Naturalist." He maintained his connection with this journal until his death, becoming in 1887, its editor-in-chief and sole proprietor. Professor Cope was a member of the Academy of Natural Sciences of Philadelphia, of the American Philosophical Society, and of many other scientific associations. He was president of the American Association for the Advancement of Science in 1896, and his address as retiring president was to have been read before the annual meeting in August, 1897.

Professor Cope's investigations and contributions to science were connected successively with the following subjects: (a) herpetology; (b) ichthyology; (c) mammalogy; (d) philosophy. In reviewing his work, this division of the field of his labors will be recognized.

(a.) *Herpetology.*

From early boyhood, Cope was greatly interested in reptiles, particularly snakes, and the collection, description and classification of recent and extinct reptilian forms were always his favorite study. His investigation in this field began in 1859, and when twenty-four, he had worked out a new classification of the Anura, based on structural characters. A few years later he made a similar classification of the lizards. These classifications have been accepted by scientists and have entirely superseded the older classifications based on external resemblances.

Professor Cope's attention was first called to extinct reptilian forms in 1865. His study of the Reptilia of New Jersey, Maryland, and Virginia was summarized in one of his most important papers, "Synopsis of the Extinct Batrachia, Reptilia and Aves of North America," (68). In this, he proposed the great extinct order Stegocephali, to include the labyrinthodons and other huge monsters of the past, a classification that has been generally accepted by paleontologists throughout the world.

Cope's western explorations yielded rich returns. He found large numbers of hitherto unknown batrachian and reptilian fossils which he named and classified. The results of his investigations on [illegible] were brought to-

gether in the "Batrachia of the Permian Period of North America," (410). In 1889, appeared his elaborate monograph on "The Batrachia of North America," (617), in which 31 genera and 107 species are recognized, 7 of the former and 27 of the later being described for the first time by Cope himself. Professor Cope's last work in this field was a memoir on "The Reptilia of North America," completed but a short time before his death.

(b.) *Ichthyology.*

As early as 1864, Cope became much interested in living fishes and he studied not only forms from various parts of America, but also many species from South America, Africa and the East Indies.

His first paper on fishes was "On a Blind Silurid from Pennsylvania," published in 1864, (23). This was followed by "Partial Catalogue of the Cold-blooded Vertebrata of Michigan," (26, 32). While in Europe in 1863, professor Cope purchased a large collection of fish skeletons from all parts of the world, prepared by professor Joseph Hyrtl of Vienna. From a study of this collection, Cope made an entirely new classification of living fishes. In a notable paper read before the American Philosophical Society in 1870, he maintained that the primary divisions of the Teleostomi are indicated by their fin structure, and on this basis he proposed a division of the fishes into five groups. This classification is accepted and employed at the present time.

The extensive knowledge of living fishes which professor Cope had acquired peculiarly fitted him for a study of the fossil forms found in the Tertiary and Cretaceous formations of New Jersey. The outcome of these investigations appeared in two important works: "Synopsis of the Families of Vertebrata," published in 1889, (615), and "On the Non-Actinopterygian Teleostomi," published in 1891, (666). These papers first directed attention to the morphological significance of the skeleton fin structure of the ancient fishes.

In spite of errors of detail and somewhat hasty generalizations, professor Cope's work in the classification of fishes and in the description of new forms has been of great value to the science of ichthyology.

(c.) *Mammalogy.*

Prof. Cope's greatest claim to fame undoubtedly rests on his investigations of extinct Mammalia, and as a vertebrate paleontologist he may justly be ranked with Cuvier, Owen and Huxley. From the time he began his western explorations until his death, Prof. Cope devoted himself almost exclusively to the study of extinct vertebrate forms. He was one of the first to deduce the Ungulata from ancestors with quadri-tubercular molars and five-toed plantigrade feet. He then maintained that the quadri-tubercular molar in the upper jaw is derived from a tri-tubercular type, and in the lower jaw from a quinque-tubercular type or a tri-tubercular type with a heel supporting two additional tubercules. This view was triumphantly confirmed by the discovery of Phenacodus, the celebrated fossil ancestor of the Ungulata. The sub-order to which it belongs, the Condylarthra of the Lower Eocene, "stands to the placental Mammalia in the same relation as the Theromorphous order does to the Reptilian order. It generalizes the characteristics of them all, and is apparently the parent stock of all excepting, perhaps, the Cetacea."

Prof. Cope has contributed much to our knowledge of the Anchitheriidæ, Felidæ, and Canidæ of the upper Oligocene, and practically all we know of the extinct horses, camels, rhinoceroses and other ruminants and Carnivora of America. He has written a number of papers on the fauna of the Tertiary beds of Texas, of the Wind River, and the Washakie mountains. His paleontological work in the west is summarized in "The Vertebrata of the Tertiary Formations of the West," (407), Volume III., of the Hayden geological survey, which appeared in 1883. Since then the evolution of the mammalian types has been the chief subject of professor Cope's reseaches, and in most of his later writings he has attempted to trace the passage from the most ancient Vertebrata to the more recent forms.

(d.) *Philosophy.*

Professor Cope's work as a scientist began in the same year that Darwin's epoch making "Origin of Species" was given to the world. He early expressed his firm belief in the doctrine of the transmutation of species, and a greater part of his work

in vertebrate paleontology brings forward valuable data to prove that all animals of the present era are descendants from those of the past.

Cope was not, however, a follower of Darwin. He denied that there is in organism any inherent tendency to vary, and that natural selection, the basis of Darwinism, can account for the origin of species and of higher groups. Natural selection, he said, might act after variations have appeared, to preserve and perpetuate those most advantageous to the organism, but it can never produce the variations. According to professor Cope's view, variations are due to three causes: (a) the physical and chemical effects of environment; (b) the use and disuse of parts; (c) consciousness implying effort and thus producing motion. Cope, therefore, returned to the Lamarckian principle of the effect of use and disuse to explain variations; but he went further than Lamarck in that he denied that animals are passive subjects. He contended that the volition and endeavors of an animal greatly influence its own life and that of its descendants, and thus that animals in some way work out their own salvation.

The inheritance of acquired characters was one of Cope's most cherished dogmas, and he became the founder and foremost advocate of an American School of Neo-Lamarckians The evidence brought forward to support his belief in the effects of use and disuse, and in the inheritance of acquired characters was not theoretical nor experimental, but that presented by the fossil forms he himself had collected and studied. His Neo-Lamarckian views were first expressed in, "On the Origin of Genera," (53), and later supported by numerous minor theories, among which the law of "Acceleration and Retardation," is perhaps the most prominent. In explanation of this law Cope says: "The succession of construction of parts of a complex was originally a succession of identical repetitions; and grade influence merely determined the number and location of such repetitions. Acceleration signifies addition to the number and location of such repetitions during the period preceding maturity, as compared with the preceding generation. Retardation signifies a reduction of the number of such repetitions during the same time."

With this theory of "Acceleration and Retardation," Cope

associated the idea that the course of evolution was determined from the beginning of things and that "life is energy directed by sensibility or by a mechanism which has originated under the direction of sensibility." He maintained that both life and consciousness preceded organism. The later being a primeval attribute of matter and the cause and not the result of organism. This conception of consciousness Cope called. "The Hypothesis of Archæthetism," (348).

Cope took up another aspect of evolution in such papers as "On the Hypothesis of Evolution," (90); "Consciousness in Evolution," (169); "The Origin of the Will," (228). In 1887, these and other essays were collected in one volume under the title of "The Origin of the Fittest," (554). Professor Cope's later contributions to the theory of evolution were brought together, about a year before his death, in "Primary Factors of Organic Evolution," (795). This book brings forward much evidence from embryology, paleontology and breeding to support the doctrine of the inheritance of acquired characters, and is recognized, even by Cope's opponents, as a very able expression of the anti-Weismann views of inheritance.

Cope did not confine his philosophical work entirely to the different aspects of evolution, but he took up many metaphysical problems and expressed his views about them in such papers as "The Relation of Mind to Matter," (557), and "Foundations of Theism," (717).

By far the greater part of professor Cope's work falls in one of the above categories, yet his investigations in two other branches of science require a brief notice.

Cope's discovery of fossil remains of various extinct vertebrates which he was able to place in certain well known geological eras, has greatly aided American geologists in the definite determination of the relative ages of different formations in the west, and in referring them to corresponding formations in the old world.

When a boy, Cope made a collection of insects and studied their habits to some extent, but he did not continue this work or take up any other branch of invertebrate zoology. His only contributions to this department of science are brief descriptions of various lower forms, principally myriopods, found in different cave formations in the United States, (69).

Prof. Cope was a man of quick decision, boundless energy, and great independence in thought and expression. He had keen and accurate powers of observation and a marvelous memory embracing the most minute details. Strong in his convictions, he was fearless in his criticism of men and institutions when he was convinced that he was upholding the right; yet he was ever ready to admit a mistake or correct an error when it had been proven that he was in the wrong. He possessed tireless perserverance—an attribute always essential to good scientific work—and when absorbed in his investigations he was completely forgetful of his own personal comfort, going for long periods without food or rest.

Undoubtedly Cope's greatest genius showed itself in his quick recognition of the theoretical significance of each of his brilliant discoveries and of their relation to the whole structure of science. His generalizations have often, at first, been discredited, sometimes ignored; yet they have frequently been substantiated by evidence brought forward on the discovery of new fossil forms and have been accepted by those who had vigorously opposed them.

Prof. Cope's capacity for work was enormous, and his published works fill many large volumes. Dr. Baur writes of him, "There never has been a naturalist who has published so many papers upon the taxonomy, morphology and palæontology of the Amphibia and Reptilia as professor Cope." His writings were by no means confined to these subjects, as a glance at the bibliography accompanying this sketch will show. He has described nearly 1,000 species of fossil vertebrates and with every description there is an accurate conception of the relation of the form described to other extinct and living forms.

In his writings, Cope is always concise and intelligible. He states clearly his opinion of the value of certain marked features of his specimen and of the position and relations of the form described. He has been severely criticised for his hasty conclusions, inconsistency and the frequency with which he changed his views; but he was always admired by friends and opponents alike for firmly upholding and defending what he considered to be the truth. His opinions were changed only when new evidence appeared that made another view seem nearer the true interpretation of the facts.

His classification of living fishes, reptiles and amphibians would alone have given Cope an enviable reputation: but he studied recent forms only for the light they could throw on those of the past. His knowledge of extinct and living forms was probably greater than that of any other scientist of the century, and it rendered him a peer of Huxley and Owen in the paleontological field.

Professor Cope's work is more generally appreciated abroad than it is in America. Although he has been highly honored by some of the leading scientific men, he has not received the recognition here that his genius deserves. It is safe to predict that future scientists will see the full significance of his wonderful discoveries and generalizations, and that he will be justly ranked among the great biologists of the nineteenth century.

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[Contributions to the Mineralogy of Minnesota. III.]

THALITE AND BOWLINGITE FROM THE NORTH SHORE OF LAKE SUPERIOR.

By N. H. Winchell, Minneapolis, Minn.

Thalite. During the survey of the Northwest (Wisconsin, Iowa and Minnesota) under the direction of Dr. D. D. Owen, a substance was found on the north shore of lake Superior at several points, which was examined by Owen and named thalite.* He found it to be a hydrated silicate of alumina and magnesia combined with what he considered a new earth "intermediate between magnesia and manganese," with specific gravity 2.548, not found crystallized, and composed as follows:

Silica	42.00
Alumina	4.06
Magnesia	20.50
Iron protoxide	1.50

*Geological Report on Iowa, Wisconsin and Minnesota, p. 600.

Potash	0.80
Manganese	trace
New earth, not taken up by sal ammoniac	10 to 12 p. c.
Water	18.00

He remarked that: "Leaving out of account the supposed new earth the chemical composition comes nearest to saponite and soapstone." He reports it from the vicinity of Baptism river.

This mineral is considered saponite by Dana.*

At the mouth of Knife river (91 B) and continuing to Gooseberry, and at numerous other places, this substance has been met with. It has marked physical characters, being quite soft, soapy to the touch, dirty white or gray, filling cavities in porous trap rock, and is sometimes very abundant, appearing where the rock is permeated by decay.

The masses containing this substance differ in structure and composition. The larger masses at Knife river are a granular aggregate, slightly pinkish white, whose hardness is between that of talc and gypsum (1.-2.). But they are often non-homogeneous, embracing, along with thalite, which gives them a general soapy feel and an apparent softness, many grains of calcite, quartz, and apparently of laumontite.

The mineral which (it is to be assumed) was examined by Owen and named thalite is found in its greatest purity in the smaller cavities, and as secondary fillings in the larger masses. It has a general amorphous appearance but in reality it is finely fibrous. It forms a jelly with HCl, and its specific gravity is 2.20.

The examination of a thin section shows vermicular crystalline aggregates which recall the ripidolites (helminth) and kaolinite. The vermicular bodies, as crossed by the random sections, present a confused and varied aspect—sometimes imperfectly spherulitic, sometimes bands formed by minute transverse fibres, sometimes bundles of fibres presenting their transverse sections, and frequently so mingled that no orderly arrangement is observable. The minute fibres, which are transverse to the vermicular bodies have positive elongation and parallel extinction. The bisectrix is n_g, parallel with the fibres and the optic angle (2V) appears small. It is to be found

*System of Mineralogy, 1892, p. 682.

in sections showing the fibres cut transversely, and, owing to the extreme fineness, requires the use of the immersion objective.

These characters isolate thalite from the vermicular chlorites and from kaolinite, from the former in having its bisectrix parallel with the fibration instead of perpendicular, from the latter in having a positive instead of a negative bisectrix. The chemical composition, determined by Owen, shows a marked divergence from that of saponite, especially if the supposed new substance be considered; and as determined by Mr. L. B. Pease, of the University of Minnesota, is as follows:

Composition of thalite.

SiO_2	42.38
Al_2O_3	7.37
Fe_2O_3	2.65
MgO	23.29
CaO	5.52
K_2O	.19
Na_2O	.36
H_2O (at 100° 10.38)	18.18
Total	99.94

Localities of thalite. Knife river; at half way between Knife river and Agate bay; Gooseberry river.

Bowlingite. In numerous instances an alteration of olivine has produced a mineral which grows in place of the olivine itself and approximately takes its form, whereas the foregoing are found in larger masses where it is probable olivine never existed. This mineral is darker colored, being greenish brown or yellowish. Taking the place of olivine it appears like an original mineral earlier than the feldspars and the augites; when cut favorably it shows two cleavages, but usually only one, and it then is distinctly and rather strongly absorptive, the darker shade recurring when the cleavage is parallel with the principal section of the polarizer. It can easily be mistaken for chlorite, when it is not well formed. It is not fibrous, but is cleaved parallel to definite crystallographic characters. The optic plane is perpendicular to the easy cleavage, and the acute bisectrix (n_p) is shown in sections parallel to this cleavage. The axial angle is small, and the interference figure is almost a permanent black cross. In sections transverse to

the easy cleavage the direction of the cleavage lines is positive with respect to the axis (n_g) of the quartz plate. Its double refraction is about the same as that of augite, but its refraction is less. This mineral is supposed to be bowlingite described by Hannay in 1877. (Min. Mag. I, 154).

Localities. Beaver Bay; Little Marais; Terrace point, and many other places.

THE LAWS OF CLIMATIC EVOLUTION.*

By Marsden Manson.

The objects of this paper are, to formulate the laws of climatic evolution, and to show:

1. That in consequence of these laws a hot spheroid, holding water and air, or fluids of similar properties within the sphere of its control, and revolving about a source of solar energy, will be subjected to a series of uniform climates, gradually decreasing in temperature, and terminating in an Ice age; that this age will be succeeded by a zonal distribution of climates, which, within certain limits, gradually increase in temperature and extent.

2. That the difficulties met in the attempts to interpret present glacial and pre-glacial climates have been due, in part, to a failure to give due weight to certain of these laws, and to recognize the force of others.

In attempting to trace the history of the earth back into the infinite past, the first step brings us in contact with the question: What was the cause of the Ice age? Before going farther it might be well to glance at the theories which have been put forward to account for this age, and to briefly consider the present position of the scientific world as regards this first step in the problem. It is not necessary to review all the theories which have been urged.† The principal ones only will be mentioned in two classes. Class I embraces those

*Read before the British Association for the Advancement of Science, Bristol, 1898.

†See The Climatic Controversy, S. V. Wood, Jr., Geol. Mag., 1876 and 1883.
Report British Assn., 1892, p. 708.
The Great Ice Age, Ed. 1894, Chap. IV., Dr. Prof. Geikie.

which require an Ice age, single in its occurrence and unique in the climatic history of the earth. The theories of this class proved unsatisfactory, and failed to fully explain the admitted facts of geology. This failure, in a measure, warranted a resort to the ingenious theories of Class II; which theories require a recurrence of glacial epochs. The lack of evidence of such recurrence has prevented the theories of this class from being generally accepted.

Class I.—(1) A decrease in the original heat of the earth.

(2) Changes in the elevation of the land areas, and consequent variations in the distribution of land and water.

(3) A period of greater moisture in the atmosphere.

Class II.—(4) Changes in the obliquity of the axis of the earth.

(5) A coincidence of an aphelion winter with a period of maximum eccentricity of the orbit of the earth.

(6) A combination of (2) and (5).

These have been frequently reviewed by various authorities. The general conclusions reached may be summed up in the following opinions:

Referring particularly to the first cause of the series, and probably the oldest, Prof. Jas. D. Whitney says:

"It is evident that the idea of connecting the phenomena of the internal heat of the globe with terrestrial climates, whether of the present or of past geological ages, must be entirely abandoned, as it has been by most writers on this subject. The hypothesis can not be allowed to stand as even one of the possible theories of climatic change." (The Climatic Changes of Later Geological Times, page 261. See also LeConte, Elements of Geology, 3rd Ed., page 381. Shaler and Davis, Glaciers, page 70.)

After an exhaustive study and review of all the principal theories, Dr. James Geikie says:

"The primary cause of these remarkable changes is an extremely perplexing question, and it must be confessed that a complete solution of the problem has not been found. Croll's Theory has undoubtedly thrown a flood of light upon our difficulties and it may be that some modifications of his views will eventually clear up the mystery. But for the present, we must be content to work and wait." (The Great Ice Age, 3rd Edition, 1894, page 816.)

After reviewing the principal theories as to the cause of the Ice age, Dr. Jos. LeConte remarks of Dr. Wallace's mod-

ification of Croll's theory (6) "This seems to be by far the most probable yet presented." (Elements of Geology, 2nd Edition, page 578.)

After a similar review, Dr. T. G. Bonney says:

"It follows from what has been said above that the low temperature which undoubtedly prevailed during the Glacial epoch has not yet received any satisfactory explanation. Each one that has been proposed is either inadequate or is attended by grave difficulties. It is therefore probable that some factor which is essential for the complete solution of the problem is as yet undiscovered, or at any rate, the importance of one which is already known has not been duly recognized." (Ice Work, Present and Past, p. 260.)

It is generally admitted, therefore, that no satisfactory solution is offered for the problem before us, and that the most distinguished scientists who have investigated the subject have no considerable number of followers, that equally distinguished co-workers accept in part only, or reject entirely the conclusions reached by their fellows.

The causes which have produced and are yet influencing the climatic evolution of our planet are so fundamental and far-reaching in their consequences that a failure to explain these causes and their mode of action constitutes a serious defect in those branches of science to which a study of these causes appertains. In the present state of physical geography and geology, the student is offered a mass of facts interpreted along various lines, each interpretation disputed by high authorities, and finally the results are summed up in the broad conclusion that "we must be content to work and wait."

Scope of the Problem. The problem of explaining this succession of climatic variations is so attractive that there is perhaps none other to which deeper thought has been directed, nor upon which such diverse views are held. In its entirety it constitutes one of the most far-reaching and grandest problems of terrestrial physics. Nor is the scope of this problem bounded by its relations to the earth. The principles and laws involved in its solution must be general.

The development now reached by each one of the planets can not be the same, and we find each in that particular phase which its mass, environment and exposure have permitted it to reach. When we trace the climatic history of the earth backward, the line of research must lead into conditions now

apparently existing upon planets in a less advanced stage. If we can predicate the conditions towards which present climatic developments are tending, these must be the apparent conditions of a more advanced planet. Thus the stages of climatic development reached by other planets should afford evidence as to the accuracy of our interpretations. In other words, the past and future stages of the earth's climatic development must be represented in a general way by the various stages now attained by one or the other of the planets of the solar system.

The Laws of Climatic Evolution.

The principal laws of climatic evolution are presented in the form of a series of postulates and corollaries.

(1) Heat rays cannot pass through fogs and clouds, formed of the vapors of a fluid having the physical properties of water, except in very greatly diminished intensity.*

(2) A hot spheroid floating in space and holding water and air (or fluids of similar properties) within the sphere of its control, gives off and receives heat subject to its passage through clouds. The spheroid must lose heat principally by the expansion of water into vapor and by radiation from the cool outer surface of its cloud envelope, which envelope is maintained by the evaporation of water by the heat of the spheroid, and conserved by heat reaching it from exterior sources; during its existence it acts as a conservator of the heat of the spheroid.

(3) That in the stages of cooling subsequent to the formation of oceans, land surfaces must, by reason of their low specific heat, cool faster than oceans; and that heat reaching the planetary surface by the circulation of meteoric or included water or by convection, or set free by denudations, faults and fractures, is principally taken up by water in its fluid and vaporous form, and conserved by water in the form of clouds.

(4) The surface temperatures of such a spheroid must be practically independent of exterior sources of heat until the greater portion of the water surrounding it be reduced to its

*Maury—Physical Geography of the Sea, 6th Ed., p. 212 et seq.
Croll—Climate and Time, p. 60.
Climate and Cosmology, p. 51.
Geikie, J.—The Great Ice Age, pp. 800-801.

point of maximum density or converted into ice, and that prior to this stage of its climatic evolution, its surface temperatures are practically controlled by interior (or planetary) heat, and are practically independent of latitude; and are therefore independent of the temperature to which the outer surface of the cloud sphere may be exposed. The effect of variations in exterior heat being mainly to increase or decrease the duration of the interior supply, and to expand or contract the sphere of cloud condensation. The principal function of exterior heat, prior to the chilling of the oceans, being conservative or to replace in part the heat lost by radiation from the cold outer surface of the cloud sphere.

(5) That until the exhaustion of the available internal heat supply, outside of a crust of low conductive power, the surface temperatures of the spheroid must be nearly uniform from pole to pole, varying only with elevation above sea level, or from local causes, such as the influence of lava outbursts upon the areas to the leeward of such outbursts. And that a series of uniform climates must prevail independent of latitude, and gradually decreasing in temperature as the spheroid loses heat.

(6) That the low specific heat of land areas permits them to cool more rapidly and to reach glacial temperatures before the oceans are reduced approximately to the point of maximum density, and consequently that snow must accumulate upon these areas until the oceans cease to give off sufficient vapor to shield the earth from solar energy. That these accumulations of snow must reach their maxima along belts of maximum precipitation, and must be independent of latitude.

(7) That upon the chilling of the oceans, the supply of vapor maintaining the cloud envelope is cut off, and the atmosphere deprived of the greater portion of its heat-intercepting power; and that heat rays from exterior sources then reach the planetary surface in sufficient quantity to dominate its climates. That a new distribution of temperatures is thereby inaugurated, dependent principally upon latitude or exposure to exterior sources, and modified by elevation and local causes.

(8) That solar rays by contact with the planetary surface are partly converted into dark or obscure rays and are trap-

ped,* or are selectively absorbed.† That a gradual accession of heat must be thereby inaugurated, resulting in the removal of glacial conditions, and that such removal of glacial conditions must be on lines determined by the degree of exposure to solar energy, and by the susceptibility of the different portions of the globe to be influenced by such exposure. That these new conditions must inaugurate a new distribution of temperatures ranged in zones and subject to solar control.

The necessary corollaries of these postulates are:

(a) That a planet having water and air within the sphere of its control, and which has not yet exhausted its internal heat, must be densely shrouded in clouds, whose outer surface presents a high albedo.

(b) That a planet whose internal heat has been practically exhausted, and which holds water and an atmosphere within the sphere of its control must reflect solar energy deficient in those rays which are most readily trapped, or selectively absorbed by its atmosphere, and it must have a low albedo, and that the color of its reflected rays must be controlled by those least readily utilized and trapped.

(c) That glacial conditions may exist locally during any period of a planet's climatic evolution provided there be regions sufficiently elevated; but that an Ice age occurs as its oceans are finally exhausted of their available remnant of planetary heat, that this age marks the period during which surface temperatures pass from interior to exterior control, or is the transition period of its climatic evolution, and is unique.

(d) There are two great eras in the climatic evolution of a planet: 1st, the era during which its internal heat controls its surface temperatures, and solar heat acts principally as a conservator of interior heat; 2nd, the era of solar control of climates, the former being an era of gradually decreasing temperatures, of uniform distribution at sea level; and the latter an era of gradually rising temperatures of a zonal distribution. The two eras, so far as land areas are con-

*Tyndall—Proc. Royal Soc., Vol. XIII, p. 160. Phil. Trans., Vol. 152, p. 95. Archives des Sciences, tom. V, p. 293.

†Langley—Investigations on the Action of the Atmosphere on Solar Radiation. Mem. Nat. Academy of Sciences, 1885-7.

Buff—Archives des Sciences, tom. LVII, p. 293.

cerned, must be separated by an Ice age. The difference in the specific heat of land, and that of water, permits the land areas to cool first. The precipitation of snow upon them must therefore have been cumulative, until the oceans were reduced to about the point of maximum density.

It is reasonably certain that glacial conditions were first removed from equatorial regions, and that maximum glaciation of land areas in temperate latitudes may have occurred subsequent to the inauguration of solar control over equatorial latitudes, and that polar glaciations may have reached their maximum at a period subsequent to the commencement of the disappearance of glaciations in temperate latitudes.

(e) The accession of solar heat by the trapping process being the result of a positive difference between the rate of receipt and the rate of loss, and not being a function of the orbital distance, a rise in temperature may as certainly follow in one position as another.

(f) That glacial conditions, although imposed upon lines independent of solar exposure, must have reached their maximum upon areas subject to maximum precipitation, and as the movement of the atmosphere in temperate latitudes is towards the east, the west coasts of continents are more exposed to moist winds and hence were more deeply glaciated than the east coasts. The narrow North American continent was thus more exposed to glaciation from the wide Pacific, than was the broad Euroasian continent from the narrow Atlantic.

(g) That the northern hemisphere of low specific heat has progressed further in climatic development than has the southern hemisphere of high specific heat. Similarly, the Atlantic has been warmed to a greater extent than the Pacific.*

*It will probably be noted that no mention is made of light rays; these can be filtered out by clouds and pass through in greatly diminished intensity. It is not considered necessary to discuss their influence at this point, as their effect is slight at temperature approximating the freezing point. The gradual development of visual organs and the development of all other senses prior to that of sight are lines of investigation which the author has not been permitted to make for want of time and means.

Brief Review of Past Climatic Conditions.

The evidence of rising temperatures since the Ice age. The elementary laws of climatic evolution having been briefly deduced and formulated, it may be necessary to revert to the geological record of past climatic conditions, and to note whether they agree with these laws.

Commencing at sea level near the polar circles, at an elevation of a few thousand feet above this level in temperate latitudes, and at a still greater elevation in tropical latitudes glacial ice is found to rest upon the land. Adjacent to this ice are found evidences of previous extension. It matters not whether the glacier be the dwarfed remnant left on the summit of the mountains of tropical Africa* or South America† or the great glaciers of Alaska or Greenland,‡ once greater extension is a characteristic and general fact noted by all observers.

The evidences of this retreat near the base of the glacier is not disputed. But as the distance from the living glacier increases the evidence of ice action becomes fainter; the traces of this action are more modified by decomposition and denudation and more deeply covered with vegetable mould, as we recede either in altitude or latitude from the living glacier. Nowhere is this better marked than at uniform levels above the sea on the west coast of North America. Here in latitude 40 to 45 degrees, the geologist finds types of topography built up or shaped by ice action, yet so modified and buried beneath successive growths of conifers that only the trained eye of the close observer can follow the forms and features. In the next few degrees northward, the work of the glacier is less modified and hence more distinct. Great

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*Mt. Kenia Quart. Jour. Geol. Soc., Vol. LI, No. 204, pp. 675-6. G. F. Scott Elliott.

†Travels among the Great Andes of the Equator, p. 62. Note. Whymper.

‡The Glaciers of North America, Prof. I. C. Russell. See also authorities quoted by Prof. R.

Report on an Exploration in the Yukon District of the N. W. Territory.

Part B, Annual Rep. 1887, pp. 51-58, Geol. and Nat. History of Canada.

Am. Geologist, Vol. XIX, No. 4, p. 263.

Am. Geologist, Vol. XX, pp. 329-330.

forests tower over and grow upon successive generations of fallen trees, which rest upon glacial débris. Still further north, and at the same general elevations above the sea, these forests grow upon a thinner layer of dead and rotting trunks and the humus is less thick. Still more northward yet, these forest trees are found in the prime and vigor of full growth—no aged and fallen trunks encumber the ground, the roots of the living trees are buried in the gravelly, rocky soil of moraines and a thin layer of decomposing vegetable matter covers the ground. Where there is no morainic material, the thin soil gives scant roothold, and an upturned root sometimes uncovers fresh glacial scratches. From commanding positions, the glittering glacier can be seen, and as he nears its front, the observer is forced to note that the forests are of young and half grown trees, then saplings and finally the very seedlings sprout from the freshly uncovered gravel of the matchless glaciers of British Columbia and Alaska.

Now and then these young forests are uprooted and plowed under by a temporary advance of the glacier, and its gradual retreat will sometimes reveal the crushed roots and trunks of a previous advance. But the integral of successive retreats is greater than the integral of successive advances, and the forest has for thousands of years kept an accurate record of the fact, although successive generations of dead trunks, whose decay has been retarded by the moist climate of the locality, have been necessary to keep the records. In making the observations one has to traverse twenty degrees of latitude, but the observations are only typical of what can be observed in a few thousand feet of observation upon the slopes of Mt. Kenia, the Equadorian Andes, or other glacier-crowned peak of any latitude. Above the timber line, the physical evidences of glacial retreat present the same graduations of distinctness as we recede from the active glacier.

The fact that the evidence of glacial retreat grows progressively fainter as we recede from the living glacier, either in latitude or elevation, marks a progressive retreat from the equator polewards and from sea level upwards; since it is progressive it must be accounted for by progressive laws now active, and suppositions of upheavel and depression and other hy-

potheses are not necessary. The areas over which the ice invasions once extended may and probably will be wrangled over for generations to come, but no geologist nor physicist, who will take the trouble to observe a single glacier and to read what others have recorded, can dispute nor deny the fact that glacial extension has within a comparatively recent period been vastly more extensive at all latitudes than it is at present, and that successive retreat has been a marked characteristic of glacial conditions during the present era of geological time. The fact that glacial conditions are giving place to milder temperatures is recorded in all latitudes, and wherever glacial ice yet rests this record, although a slightly fluctuating one, is being legibly inscribed. The bare citation of the facts establishes the interpretation that solar energy is rewarming our planet after the chill of the Ice age—that the mean temperatures of the climatic zones now belting the earth have risen since that age, and that this rise is yet in progress.

The Widespread Temperate condition of the Tertiary. Throughout the whole of the northern hemisphere which has been reached by geologists, fossil fauna and flora have been found which establish the fact that during the Tertiary warm temperate conditions prevailed. During the middle Tertiary, palms flourished well within the Arctic zone.* Buried in bogs and mingled with gravel and boulders the bones of gigantic mammals are found in tropical Brazil.† These gigantic mammals and other types of life correspond with those found in Alaska, or in Patagonia; Tertiary life in Siberia records the same temperatures as that on the shores of the Mediterranean, so that from nearly one polar circle to the other, we are called upon to note, not only a once greater glacial extension, but also a preceding temperate age. The evidence of the existence of the one is no less conclusive than that of the existence of

*Heer. Miocene Flora of North Greenland. Brit. Ass'n.' Rept., 1886.

Brit. Ass'n. Rept. 1870, p. 88.

†Branner. The Journal of Geology, Vol. 1, No. 8, p. 767. The peculiar distribution of boulders and gravel is ascribed by Dr. Branner to wave action, and to a reversion of the order of upheavals and depressions appealed to by others to account for the Ice age. The distribution of drift, as described by Dr. B., is that which Sir H. H. Howarth considers necessary to prove the glaciation of the Amazon Valley. The Glacial Nightmare and The Flood, Vol. II, p. 495. London, 1893.

th other. Evidence of the temperate age everywhere precedes the evidence of the Ice age. In some regions the Ice age yet exists, but beneath the ice is found evidence which establishes the prior existence of milder climates.*

The Tropical Conditions of the Mesozoic and Palæozoic Ages. During the Jurassic ammonites flourished well up to the polar circles, and how much further geological research has not yet been able to determine. It would be useless to recite to the youngest students in geology the facts which could be massed to prove the universal distribution of the tropical flora and fauna of the Mesozoic and Palæozoic ages.† The manuals and textbooks of geology are overburdened with illustrations. That an age of tropical climates existed prior to the temperate age may be considered a geological fact, as it is universally taught in the textbooks of geology.

Underneath the strata of these ages lie those of the previous Cambrian and Laurentian ages, whose structure and fossils likewise mark a widespread torrid climate. Beneath these in turn are the enormously thick rocks of pre-Cambrian and Azoic ages, beyond which lie the ages preceding those of geology and reaching into the domain of cosmology. We are taught alike in the textbooks of the common schools‡ and in the profound treatises of geologists and physicists§ that during these ages the Earth "was a melted fiery ball surrounded by a thick atmosphere of gases and vapors." Of this stage of the Earth's climatic development, Sir A. Geikie says:

> "At an early period of the Earth's history, the water now forming the ocean, together with the rivers, lakes and snowfields of the land, existed as vapor, in which were mingled many other gases and vapors, the whole forming a vast atmosphere surrounding the still intensely hot globe."¶

Stages of Climatic Evolution. Various stages of climatic evolution are apparently represented in the conditions of the planets Jupiter, the Earth, and Mars. The former is of great size, and is apparently shrouded in dense clouds, and appears

*Am. Geologist, Vol. XX, pp. 343-4.

†Manual of Geology, Dana, 4th Ed., p. 711 and p. 574.

‡Textbook of Geology, Sir A. Geikie, London, 1882.

§Warren's New Physical Geography, p. 11, edited by Dr. Wm. H. Brewer of Yale. See also Essays, p. 40, Prof. S. T. Hunt.

¶Textbook of Geology, p. 33 (London, 1882).

to be in the first era of climatic evolution. The cloud sphere presents a surface of high albedo, and the heat from it is of about that intensity which we should receive by the reflection of solar energy.*

The Earth, a much smaller mass, has passed through the first era of climatic evolution, and has reached the earlier epoch of the second era; during this epoch glacial conditions are being removed and surface temperatures are slowly rising. Since the rays of the violet end of the spectrum are most easily trapped, the Earth must reflect light in which red rays predominate, and it has a low albedo.

Mars, smaller and more distant from the sun than the Earth, has apparently reached a still further stage of climatic evolution. Polar snow caps form in winter and melt off in summer,† thus indicating milder polar conditions than prevail within our polar circles. The albedo of Mars is low, and solar energy reflected from its surface is deficient in violet rays, thus showing that the atmosphere of Mars, like that of the Earth, most readily traps the rays of the violet end of the spectrum. Thus Mars is apparently in a condition towards which the climatic evolution, now in progress upon the Earth, is tending.

Conclusions. The author therefore holds: (1) that the present zonal distribution of climates is gradually increasing in temperature and extent; (2) that the rise in temperature is due to the trapping of solar heat by the lower layers of the atmosphere; (3) that this rise in temperature was inaugurated at the culmination of the Ice age in tropical latitudes, and that it must be gradually checked by a denser cloud formation as the surface temperatures of the oceans are raised;‡ (4) that the Ice age was unique in the climatic history of the earth, and the result of the laws previously cited; (5) that preceding climates were independent of latitude and were

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*Young's General Astronomy.

†Dr. E. E. Barnard, Popular Astronomy, No. 20, 1895. See also Young's General Astronomy, p. 337.

‡The equatorial cloud ring is possibly the nucleus of a more extended ring which will protect a greater area from noon and afternoon exposure to direct solar energy. As evaporation was reduced to a minimum at the culmination of the Ice age, cloud formation and precipitation, being direct functions, were likewise at a minimum and this ring was then probably of less extent.

controlled by the internal or planetary heat of the earth, that they were the result of the cooling of a hot spheroid subjected to the gradual loss of heat by the evaporation of water to vapor, by the radiation of heat from the cool outer surface of the resultant cloud sphere, which loss by radiation was retarded by the conservative action of solar energy; (6) that local glaciations could have occurred during any period and in any latitude, provided there were land areas sufficiently elevated.

Difficulties in Previous Explanations.

The postulates and corollaries just given appear to the author to satisfactorily account for the great variations in climate geologically recorded in the history of our planet. The difficulties met with in previous attempts to explain present, glacial and pre-glacial climates have been due in part to a failure to give due weight to certain of the laws which are above cited, and to fully recognize the force of others. For instance:

(1) The influence and functions of water in its various forms upon the mode and rate of loss of planetary heat have not been given due weight.

(2) The effect of the difference in the specific heat of land and water has been omitted in most of the discussions.

(3) The conservative function of solar energy prior to the exhaustion of planetary heat has not been fully recognized.

(4) The ultimate influence of the trapping of solar energy in the lower layers of the atmosphere, and the cumulative effect of this action upon surface temperatures has been left out of consideration.

(5) That the acceptance of ice action alone as a proof of a glacial epoch is not warranted.

The failure to fully weigh and adjust the effects of the laws of climatic evolution has almost necessitated a resort to assumptions and hypotheses, some of which have been of a vague and indefinite nature, and others rest upon an inadequate foundation. Of these may be cited: Variations in the amount of solar energy, in the heat absorbing power of the solar atmosphere, in the temperature of space, in the direction and temperature of the gulf stream, in the elevations and depressions of land areas, and in changes in position of the

polar axis, and in the orbital eccentricity of the earth. Some of these are beyond the range of analysis and investigation, and others are of local and minor influence, and may be left out of consideration in a discussion of the fundamental principles.

If the eras of climatic evolution which our planet has undergone have herein been referred to their proper laws and sequence, the questions involved may not be the fearful "glacial nightmare" that some would make them; but rather the means whereby we recognize the Ice age as one of these eras, during which the land areas were made smoother and more stable, and the soils more uniform in composition and fertility.

If new light has been thrown on the grand problems of terrestrial physics, much remains to be done. The worshipers who bow at the altars of science will have a stronger faith to cheer them on; and if some of their early structures have been rudely struck, it is hoped that in their stead grander and more stately temples will be reared whose foundations rest upon everlasting truth.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Fossil Medusæ. By C. D. WALCOTT. (U. S. Geol. Surv. Monographs. Vol. XXX, Washington, 1898.)

This magnificent volume, so thorough in its treatment of the subject, and so profusely illustrated, is a most valuable gift of the U. S. Geological Survey to the scientific world.

Fortunately as the known fossils of the Medusæ are comparatively few, Mr. Walcott has been able to present in this volume a complete review of the organic remains of this order hitherto found in the Paleozoic and Mesozoic rocks.

The fossil Medusæ so far discovered belong chiefly to the Cambrian and the Jurassic systems, and to these the memoir is almost entirely devoted. They have been found mostly at two points in the Appalachian range in America and in Sweden and Bavaria in Europe. About one-half of the text of this memoir is devoted to a description of the former, and the second half to a reproduction of the accounts, scattered in several periodicals, etc., which describe the European Medusæ.

The American species are all Cambrian and belong to four genera, Brooksella Laotira, Dactyloidites and Medusina. The two former are now described for the first time, and have been obtained from silicious nodules of the Coosa valley, Alabama, first observed and collected by Dr. Cooper Curtice. The Medusæ occur plastered upon and imbedded in the silicious nodules (called "star cobbles") which have been contained in a yielding shale.

The first twenty pages of the memoir are devoted to a description of the mode of occurrence of these interesting fossils, and of the lithological and chemical peculiarities of the nodules which are the medium of their preservation. The question of their relation to the sponges is also discussed.

Of the two genera described from this locality Brooksella is the more simple form. This genus is referred by the author with doubt to the suborder Rhizostomæ of the Discomedusæ and *Cannorhiza connexa* is considered the nearest living form. Mr. Walcott illustrates this by a restoration of *Brooksella alternata* and a section of the species above named; the structural relation is quite marked, and all the essential part of a Discomedusan appear to have been recognized, except the reproductive organs.

Laotira is a more complex structure. Some examples are simple, like Brooksella, others are compound structures supposed to be produced by fission, as in some living Medusæ. In the compound forms the regular radial symmetry is more or less obscured, and a bilateral symmetry prevails. Diagrammatic representations are given of three conditions of Laotira, from the simple to the most complex. No reproductive organs have been observed in Laotira, in which the increase of individuals is supposed (as above observed) to be due, in part at least, to fission. All the varieties observed are referred to one species, *Laotira cambria*.

The above species of fossil Medusæ were found in the Middle Cambrian rocks of Alabama, but a form which is now referred to the Discomedusæ by Mr. Walcott was found some years ago in slates, referred to the Lower Cambrian, in Middle Grenville, New York. This was taken by the discoverer, Dr. Asa Fitch, to be a seaweed, and described as *Bothotrephis? asteroides*. Subsequently it was more fully described by Prof. Jas. Hall under the generic name of Dactyloidites. He thought it referable to sponges or possibly to marine algæ.

Unfortunately all the examples of this fossil are completely flattened out, and consist of scarcely more than a faint dark stain on the layers of the slate. Mr. Walcott has found a few raised somewhat in relief, and by comparison with the Middle Cambrian forms of the Coosa valley has been able to satisfy himself that the impressions are those of a species of the Discomedusæ. A similar form has been found at Parker's quarry, Georgia, Vt.

About twelve pages of Mr. Walcott's memoir are taken up with a description of the Lower Cambrian Medusæ of Sweden and Bohemia,

and tracks occurring in the sandstone in which the Medusæ are found. Dr. Torell, the first describer of these Medusan remains, referred them to corals. Dr. Linnarsson, who followed in their interpretation, thought they were sponges. Finally Dr. Nathorst, who went into a very careful study of the object, concluded they were Medusæ, and referred them to the genus Medusites, now changed by Mr. Walcott to Medusina. These Swedish fossils were thought to be casts of the gastric cavity, etc., of Discomedusæ which had been thrown upon a sandy shore, and partly filled with sand, forming a mold of the interior, before they perished. Three species were described by the Swedish naturalist from these Lower Cambrian rocks.

In connection with the account of these remains Mr. Walcott gives a history of the discovery and elucidation of the curious fossil Eophyton, so abundant in some portions of the Cambrian rocks. Eophyton had been described by Dr. Torell in 1868, two years previously to the account given by him of the Medusan remains, and since then has been referred to and commented on by various authors. The first describer and Dr. Linnarsson thought it was a plant of higher organization than a seaweed. Later observers, as Nathorst, Dawson and Dames, regarded these markings as made by Medusæ or other animals. Saporta goes back to the old idea that they are prints of seaweeds, though he admits that some are possibly trails of seaweeds. Mr. Walcott concludes that it is quite probable such markings may be produced as Nathorst has suggested by Medusæ, though he thinks there is little doubt that others owe their origin to the trailing of algæ over the sea bottom, especially in shallow water, where the tide was running out. He has observed such trails many feet in length in direct lines, without a bend or interruption, made by drifting algæ.

Nearly a dozen varieties of Eophyton have been described by various authors as species.

About thirty pages of this work are devoted to a description of the Jurassic and Permian Medusæ of Central Europe. Mr. Walcott has conferred a boon on American students by giving full descriptions of these fossils with admirable figures and analyses of the structure, mostly taken from Hæckel's and Brandt's studies of the species. Half of the Jurassic forms are referred to two suborders of the Discomedusæ, viz.: Semostomæ, Agassiz, and Rhizostomæ, Cuvier; the other half are referred to *Medusites*, as not being capable of classification in the suborders above named. Twelve species are described, all of which, except one, appear to have been determined by Hæckel. Only one species, *M. atava*, has been described from the Permian.

Among objects classified as "Incertæ sedes," are the Medusæ of the Cretaceous of northern Germany, of which a few species have been described, and which in this work are referred to the sponges; and G. F. Matthew's genus Medusichnites proposed for tracks supposed to have been made by the tentacles of Medusæ. Of these trails it is thought by Mr. Walcott that one which he figures may have been produced by Medusæ, all the others he thinks are of inorganic origin.

One admirable feature of this volume is the profusion of plates, in which neither pains nor expense has been spared. Four plates are given to the new species Brooksella, eighteen to Laotira, three to Dactyloidites, three to the Swedish Medusæ, two to Eophyton, seven to the Jurassic species of Bavaria, one to Medusichnites, etc. There are also twenty-five wood cuts scattered through the text.

On the whole this volume is a most important contribution to a branch of paleontology which is scarcely within reach of the ordinary student, but there are some points on which one would desire further information. Mr. Walcott has suppressed the genus Medusites and substituted the new genus Medusina, on the ground that the former was founded in error; i. e., that the type species was really a Lumbricaria. Medusites has been used for thirty years past, and by such men as Kner, Leuckart, Hæckel, Nathorst, F. Schmidt and von Ammon, and with the means of illustration at his command it would have been more satisfactory if Mr. Walcott had reproduced Germar's original figure and description; then the establishing of the new genus would have been more satisfactory and convincing.

Another thing which seems to come up in this connection is the genus Eophyton. This name was given by Torell on the supposition that the objects represented were plants, not mere sea-weed, but plants of high organization, comparable to Cordaites.

Very few who have given these objects careful study will agree with Torell as to their cause, or think they are plant remains of any kind. Mr. Walcott himself does not think so. Here, then, is a species whose name conveys an erroneous meaning, yet the author of this work, while he has dismissed Medusites as founded in error, retains Eophyton.

It would be satisfactory also to some readers of this volume if a little more time had been given to explain why the objects referred to Medusichnites are thought to be of inorganic origin; the reasons given in the original description for supposing them to be of organic origin, are not in any way met.*

One might also raise a protest against the practice inaugurated by Dr. Nathorst of making tools whereby to imitate natural markings, as, for instance, Cruziana; not because there is anything wrong in the act, but because the resulting impressions are apt to be misinterpreted. The stiff prints left by these tools, do not in any way represent the infinite variety of mood in Cruziana, as shown in the varying trails of a single species. The prints made by such tools are about as near to the natural object in appearance, as the wood-carver's rose or thistle are to these flowers as they bloom in the field. Akin to this method is that of producing trails of Medusæ by artificial means and making them on a wet emerged surface, in place of the fine submerged mud of the sea-bottom; the motions and markings in the emerged surface are involuntary, and not the natural motions (of the tentacles of a Medusa, for instance). There is always the possibility of intro-

*Trans. Roy. Soc. Can., Vol. viii, sec. IV, p. 145.

ducing the personal equation in an experiment of this kind, and while it may be involuntary on the part of the animal, it may be voluntary (but unconsciously so) on the part of the experimenter. G. F. M.

Uber die Fauna der Bande f. 1. im mittel böhmischen Silur. Von J. V. ZELIZKO. --also—*Beitrag zur Kenntniss des Mittelcambrium von Jénes in Böhmen.* Von J. V. ZELIZKO. (Verhandl. d. K. K. geol. Reichsanstallt, Nr. 9 und 10, 1898, und Nr. 16, 1887, Wien.)

These two pamphlets describe the result of the exploration of certain fossiliferous localities in Bohemia; at some of which the beds of Bande f.1. of the Silurian are exposed, and at others the Paradoxides beds. The gradual increase of the fauna of Bande f.1. in the lower part of the Silurian to its disappearance in the upper part are shown.

In the Cambrian beds several species rare to Barrande were obtained more plentifully and the geographical range of others extended. No figures or plates. G. F. M.

The educational series of rock specimens collected and distributed by the United States Geological Survey. By JOSEPH SILAS DILLER. (U. S. Geol. Survey, Bull. 150, 400 pp., 47 pls., 1898.)

This series of rock samples, already distributed by the United States Geological Survey to the leading educational institutions of the country, is here described in considerable detail. But prefacing the descriptions is a chapter on the study of rocks, written in a style which is as free from technicalities as is consistent with the nature of the subject. This chapter contains: an account, with descriptions, of the structural features of rocks; an account of the methods of physical analysis of rocks; concise descriptions of the chief characters of the common rock-forming minerals, with references to specimens of the series containing each mineral; and a short section on the classification of rocks. These subjects are discussed in a manner which can be readily understood by the intelligent student, and this chapter thus forms a fitting introduction to the detailed descriptions which follow.

The main part of the work is devoted to the description of the rock specimens. Each is taken up by itself and described macroscopically and in nearly all cases also microscopically. Accompanying the descriptions are many illustrations, frequently microphotographs. Chemical analyses are given of many of the specimens, and there are references to other sources of information concerning the rocks and the geological phenomena which they represent. The specimens are grouped under eight heads, as follows, with the number of specimens in each group: unaltered sedimentary rocks of mechanical origin, 22; unaltered sedimentary rocks of chemical origin, 16; unaltered sedimentary rocks of organic origin, 18; unaltered igneous rocks, 58; metamorphic sedimentary rocks, 21; metamorphic igneous rocks, 11; residual rocks, 4; illustrations of surface modifications, 6;—156 in all.

A large part of the descriptions were written by Mr. Diller, but quite a number were written by other geologists. This latter fact has caused a certain lack of uniformity in the manner of the descriptions and in the kinds and number of facts presented. To offset this dis-

crepancy, if it be one, is the fact that the rocks described by each individual are those with which he is very familiar and which consequently he would seem best fitted to describe. The collection and distribution of these rock specimens and the writing of the necessary descriptions must have been a long and arduous task, and both Mr. Diller and the Survey are to be congratulated on its successful completion.

U. S. G.

MONTHLY AUTHORS' CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

Abbe, Cleveland, Jr.

An episode during the terrace cutting of the Potomac. (Johns Hopkins Univ. Circulars, vol. 18, pp. 16-17, Nov. 1898.)

Ashley, G. H.

Note on an area of compressed structure in western Indiana. (Bull. Geol. Soc. Am., vol. 9, pp. 429-431, Dec. 1, 1898.)

Bagg, R. M., Jr.

The occurrence of Cretaceous fossils in the Eocene of Maryland. (Am. Geol., vol. 22, pp. 370-375, Dec. 1898.)

Beede, J. W.

Notes on Campophyllum torquium Owen, and a new variety of Monopteria gibbosa Meek and Worthen. (Kansas Univ. Quart., ser. A., vol. 7, pp. 187-190, Oct. 1898.)

Beede, J. W.

Preliminary notice on the correlation of the Meek and Marcou section at Nebraska City, Nebraska, with the Kansas Coal Measures. (Kansas Univ. Quarterly, ser. A, vol. 7, pp. 231-233, Oct. 1898.)

Blake, W. P.

[Report of the territorial geologist of Arizona.] (Report of the governor of Arizona to the Secretary of the Interior for the fiscal year ending June 30, 1898, pp. 19-86, 1898.)

Case, E. C.

The development and geological relations of the vertebrates. III., Reptilia, continued. (Jour. Geol., vol. 6, pp. 711-735, Oct.-Nov. 1898.)

[Cope, E. D.]

Memoir of Edward D. Cope. By W. B. Scott. (Bull. Geol. Soc. Am., vol. 9, pp. 401-408, Dec. 1, 1898.)

Crane, W. R.

Geography and detailed stratigraphy of the Kansas Coal Measures;

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*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Description of mines, mining methods, and mining machinery; chemical and physical properties of Kansas coals; output and commerce; mining directory; and mining laws. (University Geol. Survey of Kansas, vol. 3, pp. 107-336, pls. 31-70, 1898.)

Cushing, H. P.

Report on the boundary between the Potsdam and pre-Cambrian rocks north of the Adirondacks. (16th Ann. Rept. State Geol. of New York, 27 pp., 1 map, 1898.)

Dall, W. H.

Contributions to the Tertiary fauna of Florida, with special reference to the Silex beds of Tampa and the Pliocene beds of the Caloosahatchie river, including in many cases a complete revision of the generic groups treated of and their American Tertiary species. Pt. 4. Prionodesmacea and Teleodesmacea. (Wagner Free Inst. Sci., Trans., vol. 3, pt. 4, pp. i-viii and 571-947, pls. 23-35, Apr. 1898.)

Darton, N. H.

Discovery of marine Cretaceous in boring at Norfolk, Virginia. [Abstract.] (Bull. Geol. Soc. Am., vol. 9, pp. 414-416, Dec. 1, 1898.)

Dawson, J. W.

Note on Lepidophloios cliftonensis. (Bull. Geol. Soc. Am., vol. 9, p. 416, Dec. 1, 1898.)

Diller, J. S.

The educational series of rock specimens collected and distributed by the United States Geological Survey. (U. S. Geol. Survey, Bull. 150, 400 pp., 47 pls., 1898.)

Eakle, A. S.

A biotite-tinguaite dike from Manchester by the Sea, Essex county, Mass. (Am. Jour. Sci., ser. 4, vol. 6, pp. 489-492, Dec. 1898.)

Eakle, A. S.

Topaz crystals in the mineral collection of the U. S. National Museum. (U. S. Nat. Museum, Proc., vol. 21, pp. 361-369 [no. 1148], 1898.

Gannett, Henry.

A gazetteer of Kansas. (U. S. Geol. Survey, Bull. 154, 246 pp., 6 pls., 1898.)

Gannett, Henry, and Mathews, E. B.

Report on the cartography of Maryland. (Maryland Geol. Survey, vol. 2, pp. 243-488, pls. 33-48, 1898.)

Geikie, James.

Earth sculpture or the origin of land forms. (xiii and 397 pp., 2 pls.; The Science Series, G. P. Putnam's Sons, New York, 1898.)

Gratacap, L. P.

Relation of James Hall to American Geology. (Am. Nat., vol. 32, pp. 891-902, portrait, Dec. 1898.)

Grinnell, G. B.

Northern Rocky mountain glaciers. (Science, new ser., vol. 8, pp. 711-712, Nov. 18, 1898.)

[Hall, James.]

Relation of James Hall to American Geology. By L. P. Gratacap (Am. Nat., vol. 32, pp. 891-902, portrait, Dec. 1898.)

Haworth, Erasmus.

Stratigraphy of the Kansas Coal Measures. (University Geol. Survey of Kansas, vol. 3, pp. 9-105, pls. 1-30, 1898.)

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Another episode in the history of Niagara falls. (Am. Jour. Sci., ser. 4, vol. 6, pp. 439-450, Dec. 1898.)

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On some turtle remains from the Ft. Pierre. (Kansas Univ. Quarterly, ser. A, vol. 7, pp. 201-203, Oct. 1898.)

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On some additional or imperfectly understood fossils from the Hamilton formation of Ontario, with a revised list of the species therefrom. (Geol. Survey of Canada, Contributions to Canadian Paleontology, vol. 1, pt. 5, pp. 361-436, pls. 48-50, 1898.)

Williams, H. S.

The classification of stratified rocks. (Jour. Geol., vol. 6, pp. 671-678, Oct.-Nov. 1898.)

Winchell, N. H.

Thomsonite and lintonite from the north shore of lake Superior. (Am. Geol., vol. 22, pp. 347-349, Dec. 1898.)

PERSONAL AND SCIENTIFIC NEWS.

THE REGENTS OF THE UNIVERSITY of the State of New York have decided to divide the work in geology and paleontology which was for so many years in charge of the late professor James Hall, and in so doing have erected two coordinate departments, one of paleontology and stratigraphic geology and the other of "pure geology," the latter to cover dynamic and physical geology, the crystalline rocks, surficial geology, etc. They have appointed to the charge of the former, professor John M. Clarke, with the title of state paleontologist and to the latter, Dr. F. J. H. Merrill with the title of state geologist.

They have also appointed Dr. E. P. Felt to the position of state entomologist as successor to the late Dr. J. A. Lintner.

DR. C. WILLARD HAYES and MR. ARTHUR W. DAVIS, who have been absent for over a year in connection with geological and hydrographical work for the Nicaragua Canal Commission, have returned to Washington.

GEOLOGICAL SOCIETY OF WASHINGTON. At the meeting of Dec. 7 the following papers were presented: Mesozoic stratigraphy of the southern Black hills, N. H. Darton; Ripple marks and cross-bedding, G. K. Gilbert; The glaciated region of the Sierra Nevada, H. W. Turner.

PROF. G. FREDERICK WRIGHT, of Oberlin College, has made plans for a trip around the world in 1900, for the purpose of studying geological phenomena. He will visit Hawaii, Japan, cross Asia, following the line of the new Siberian railroad, studying especially the Siberian glacial drift, a field as yet untouched; thence, after a study of the region around the Caspian sea, he will return to the United States, the whole trip occupying about nine months. (*Science.*)

THE AMERICAN NATURALIST for December announces that the present editor-in-chief, Dr. Robert P. Bigelow, of the Massachusetts Institute of Technology, finds it impossible to continue to devote to that magazine the time required for its management and so relinquishes his charge of the

magazine with the current issue. A successor to Dr. Bigelow has been found, but his name is not announced.

GEOLOGICAL SOCIETY OF AMERICA. The following is the preliminary list of papers to be presented at the eleventh winter meeting, Columbia University, New York city, Dec. 28 to 30, 1898.

The Archean-Potsdam contact in the vicinity of Manitou, Colorado. W. O. Crosby.

Pre-Cambrian fossiliferous formations. C. D. Walcott.

Outline of the geology of Hudson's bay and strait. Robert Bell.

The faunas of the Upper Ordovican in the lake Champlain valley. T. G. White.

Stratigraphy of the Pottsville series in Kentucky. M. R. Campbell.

American homotaxial equivalents of the original Permian. C. R. Keyes.

The Newark system in New York and New Jersey. H. B. Kümmel.

The Conshohocken plastic clays. T. C. Hopkins.

Discovery of fossil fish in the Jurassic of the Black hills. N. H. Darton.

Mesozoic stratigraphy in southeastern Black hills. N. H. Darton.

Relations of Tertiary formations in the western Nebraska region. N. H. Darton.

Shorelines of Tertiary lakes on the slopes of the Black hills. N. H. Darton.

The Iroquois beach at Toronto and its fossils. A. P. Coleman.

The granites on the north shore of Long Island sound with some observations on the granites of the Atlantic coast in general. J. F. Kemp.

Metamorphosed basic dikes in the Manhattan schists, New York city. J. F. Kemp.

Augite-syenite near Loon lake, N. Y. H. P. Cushing.

On the phenocrysts of intrusive igneous rocks. L. V. Pirsson.

Geology of the crystalline rocks of Manhattan island and vicinity. F. J. H. Merrill.

The gold-bearing veins of Bag bay, western Ontario. Peter McKellar.

Origin of the grahamite in Ritchie Co., W. Va. I. C. White.

Surface features of northern Kentucky. M. R. Campbell.

Geology of the Yosemite national park. H. W. Turner.

Ripple-marks and cross-bedding. G. K. Gilbert.

A remarkable landslip on the Rivière Blanche, Portneuf county, Quebec. G. M. Dawson.

Origin of the Highland gorge of the Hudson river. F. J. H. Merrill.

The wind deposits of eastern Minnesota. C. W. Hall and F. W. Sardeson.

Ice sculpture in western New York. G. K. Gilbert.

The Iowan drift. Samuel Calvin.

General geology of the Cascade mountains in northern Washington. I. C. Russell.

The supplementary list of papers, issued Dec. 15, contains the following titles:

Geology and archeology of the California gold belt. W J McGee.

Geology and physiography of the West Indies. R. T. Hill.

Volcanoes of southeastern Russia. H. F. Reid.

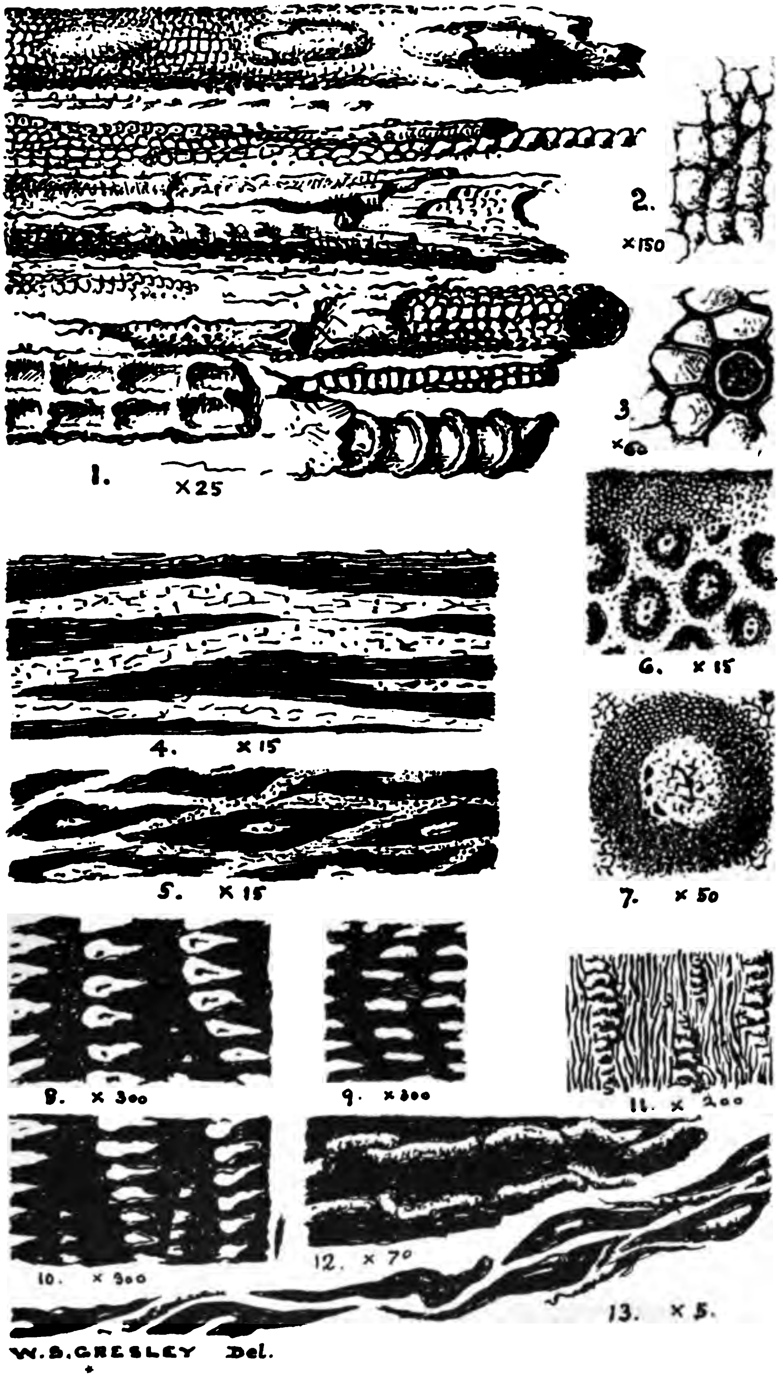
Structure of the Iola gas field, Allen Co., Kansas. Edward Orton.

Gold mining in the Klondike district. J. B. Tyrrell.

Glacial phenomena in the Yukon. J. B. Tyrrell.

The Nashua Valley glacial lake. W. O. Crosby.

An unrecognized process in glacial erosion. W. D. Johnson.



STRUCTURES IN COAL.

THE

AMERICAN GEOLOGIST.

VOL. XXIII. FEBRUARY, 1899. No. 2

SIDE-LIGHT UPON COAL FORMATION.

By W. S. GRESLEY, F. G. S., F. G. S. A. (Mining Engineer.)

(Plate II.)

1. The subject of the origin and formation of coal will always be one of much interest so long as there is anything *new* to be said or *left to be found out* concerning it. While all investigators seem to be agreed that coal (all varieties of coal) is of vegetable origin, they are by no means of one mind as to at least two very important points, namely: (1) *the true character of the different kinds of plants involved*, and (2) *the manner or ways in which these vegetable constituents, including residual products, were accumulated or deposited.*

As to the differences in physical structure and the lamination and texture of coals, probably all agree that these owe their peculiarities to original differences in kind of plants and to circumstances of deposition. Moreover, no one disputes that certain coal-seams were formed differently from other; but I hold that there are serious objections to a belief in the "growth in place" theory, as generally understood, as applicable to normal coal-beds in this country as well as in Great Britain, e. g., the great "Pittsburg" seam; the "No. 2" seam of Illinois; the "Top hard" or "Barnsley" bed, in England; the "10-Yowd" of South Staffordshire, and others.

So far as microscopy has been applied to throw light upon the origin of coal, French and German scientists seem to have in recent years gone ahead of English speaking investigators; and while their claims to the more startling discoveries of new facts which relate largely to micro-organisms, both animal and

vegetable, would appear to require verification, the work of others elsewhere is beginning to make it evident that our older conceptions and beliefs must eventually be very greatly modified.

That the question of coal-bed, I do not say coal formation, is not going to be satisfactorily solved in the laboratory or under the microscope, I am confident. It is a question of close and minute examination and scrutiny of all the materials as they actually occur in and in close association with the seams of coal—in the field, which, as much if not more than anything else, is destined to rightly reveal the story. Scientists have been paying closer attention to small specimens of coal than to large blocks, thus missing the broader features that certainly must not be neglected. Unfortunately they who come in daily contact with the *seams* of coal, are not familiar with the use of the microscope, nor are they paleobotanists; the latter, on the other hand are deprived of facilities for studying coal stratigraphy. Little wonder then that different views are formed nad held regarding the same subject. Take the *stigmaria* hypothesis for instance; possibly it may be a true condition in certain cases, but mark this! do we ever get any new facts in support of it? but do we not almost every day see recorded the results of investigators which tend to weaken that hypothesis? In a spirit of open-mindedness then, let us take note of a few facts that seem to be new.

2. Many coal-beds have been reported to contain more or less conspicuous and numerous lumpy masses or flaky areas of mineral resin, ambrite, or fossil gum of some kind, and I know of several other seams containing it that do not appear to have been noticed, e. g., three seams in W. Penna.; 3 in England; 2 in Canada; 1 in Russia; 1 in Colorado; also present in coal specimens from Japan; South Africa (Natal coal); Queensland, Australia; Orange Co., California; Wyoming and in Cannel from W. Va. The fact that a similar or very similar substance, so far as judged by its physical and optical properties, more or less thoroughly permeates the blacker, more carbonaceous and brittle, shiny lustrous laminæ in coal, as well as much of the harder, duller and more granular material (in which the black laminæ are embedded) is a condition that does not appear to have been reported. The bright, clear,

garnet-red and yellowish plays of color which I have repeatedly observed upon or in the knife-edges of very thin splinters or flakes of coal, testify to the presence in it of this resinous material. Fragments of woody-looking and more succulent tissues of some of the better preserved black laminæ evidently have their cells and tubulous parts filled with solidified liquid hydrocarbons—the amber-like material. Clearly also, this material is to a large extent the cementing matrix or groundmass of the coal. To it, it seems to me, coal chiefly owes its body, solidity or its cohesive strength. It is this same substance, I claim, that gives to coal its somewhat loose or open texture (texture revealed by visible vegetable filaments, fragments and offshoots), notwithstanding its frequent close approach to homogenity in mass. In other words, the more undecomposed parts of plants in coal seem to have become not only impregnated by this liquid amber-like substance, but embedded in or surrounded by it in a manner somewhat analogous to coral-fragments, shells, etc., in the calcareous matrix of marble. Now, this mineral resin is doubtless what one or two fanciful observers have mistaken for plutonic, or volcanic, oil, which they supposed flowed from rents in the earth and collected in pools or basins, saturating the vegetable débris or producing impressions of bark, leaves, etc., on solidification. Other writers seem to be pretty sure that in this resin-like product they can detect the action of bacteria and fermentative processes upon microscopic algæ.

But whatever this substance or compound is, it is an element in coal-bed formation that plays a very important rôle. That it is not confined to *seams* of coal is proved by its occurrence in many of those perplexing pitch-coal, meandering, streaky, and vein-like forms (of endless variety of shapes and sizes) very commonly seen in the shales, fire clays, sandy beds, and bony layers associated with beds of coal, and many of which actually proceed from or are clearly traceable right into the coal-bed. The physical, stratigraphical as well as chemical composition of these pitch-coal forms *not* in the seam, so closely agree with coaly forms of similar aspect *in the seams* that here is practical evidence that whatever these coaly forms represent or were originally, they are one and the same thing or things. Moreover, where suitable specimens of both have

revealed plant tissues in them, there is close agreement; and the yellowish resin-like "body" of the plants is present in each, and carries with it sufficient evidence to make it plain that this particular vegetation was hydrocarbon-producing.

It is well known that leaves of certain plants yield a great deal of oil. Pines and conifers produce vast quantities of resins and gelose material. The coal-plant macrospores, microspores and (?) pollen are said to be convertible into mineral resin. Sea weeds and other aquatic plants yield residual products of tarry and oily nature capable, under favorable conditions, of becoming chemically coal-like solids.* We may be quite safe in assuming that the breaking-down or decomposition of much of the more woody parts of the coal-period vegetation was productive of a vast quantity of fluid resinous materials that found their way into the areas of coal accumulation, and there materially helped to make coal. Where are the remains of the aquatic or algous vegetations of the coal-period if not in the beds of coal? Perhaps—probably even—there were then more water plants than land plants. That there was a terrestrial flora is certain; that there was then more water than land is highly probable. That land plants were evolved from aquatic forms is not unlikely. Therefore we cannot ignore the supposed existence of a goodly number of water-plants as well as marsh- or swamp-loving species, in the coal-age. Thus there were probably several sources of this resin-like, cementing material operating as deposition proceeded.

3. Quite an appreciable quantity of the material of many beds of coal in North America consists of rod-like bodies (whole or in fragmentary state) about 1-50 of an inch in diameter. For the most part these rods consist of compact, shiny black, brittle, solidified hydrocarbon. Some are composed of fibres, some of plates; but most of them seem to be structureless. Occasionally the black substance gives place to semi-transparent materials of various shades of yellow, while rods of a milk-white substance are still rarer. These yellow and white substances are sometimes present in rods of coaly composition, in the form of spindle-shaped masses, disposed in single rows of disconnected beads running through

*See works of Sterry Hunt and Bischof.

the axes of the rod. Other rods again have one or-two parallel rows of square or box-shaped recesses which may or may not contain the yellowish amber or resin. I have observed these coaly rods in not a few European coals. Cretaceous coals of America also reveal them. They may often be seen in the black and gray shales interstratified with coal, and in actual contact with fish scales, teeth, etc., and little shells. Transverse or vertical sections of coal in which they occur reveal them as black dots or shortish lines crowded together or scattered, and embedded in grayish material of a dull lustre. Bedding planes of coal often reveal these rods in vast numbers. Here and there brilliant pitch-coal laminæ enclose these rods, their presence being detected because of their white, yellowish amber-like colors. Rods composed of pyrites are also well-preserved. Exteriorly these rods are variously marked or ornamented;—some partake of the impress of the cellular tissues in which they have been formed *in situ*, others are ribbed transversely or fluted longitudinally. In a series of illustrations of new(?) plant-structures in coal that I am preparing for publication, the relation of these rods to one another and to the rind of the "rod-plant," as I call it, is shown. Thus, whatever this rod-plant was, the vast abundance of rods in coal—including anthracite of Pennsylvania,—demonstrates that it was very common and very prolific. Another important point is this—that since the rods are for the most part scattered, broken, fragmentary, or not in place, they were *hard* rods before they got into the positions which they now occupy. How important this fact becomes when we consider the question of the physical and chemical condition of coal during deposition or while being accumulated; its original thickness or solidity; and the degree or extent of compression or diminution in bulk due to weight and compression of added strata as the coal measures were piled up, appears evident. For interesting remarks regarding rods of coal in the great "Pittsburg" seam, Prof. D. P. Penhallow's communication entitled "*Observations upon some structural Variations in Certain Canadian Coniferæ,*" pp. 26 and 27. Trans. Roy. Soc. of Canada, Section III, 1894, may be consulted with profit in this connection. In a paper read before the Manchester Geological Society,(England) (see Trans. Vol. XXV,

p. 525), but not yet in print, I adduced a mass of facts in support of a theory that coal-beds, as a rule, have not suffered anything like so much compression or reduction in original thickness as many writers on coal-formation have claimed—an ultimate thinning or vertical squeezing down to 1-5 to 1-12 of their original thickness; or which is the same thing, coal beds are said to have been from five to twelve times as thick as soon as completed or covered up by mud, sand, etc., as we have them today. In the light of this phenomenon of partial solidification during accumulation, and the resin-soaked aspect of coal, generally, the above teaching will have to be modified somewhat in future text-books.

4. The literature of coal-formation, so far as I know it, is most unsatisfactory relative to the probable or supposed nature and vegetable structure of the *pitch-coal* layers or laminæ, that give coal its "grain" or stratified aspect (so-called). How exceedingly variable in size and shape these black lines or plates are, all observers of coal-beds know. Looking up the opinions of authors as to the meaning of these laminæ, I find that hardly any two agree, though most seem to favor a woody origin of some kind, rather than that they represent patches or streaks of residual products having little or no organic structure. I have given much attention of late to these black laminations, both in bituminous coals and in anthracites; and, strange as it may seem, the latter have afforded the most favorable materials developing anatomical structures. Some of these tissues, etc., I purpose publishing in the near future. Now, these black laminæ are by no means all black, nor uniform in lustre, or in possessing clearly-defined and flat exterior surfaces, terminals, etc. The edges of some are wavy, ragged, spiny, etc.: the upper and lower plates or layers of some consist of closely-compacted rods, straight or twisted: or dense black in one layer while the parallel one is composed of rods. Other laminæ consist wholly or largely of wavy vertical rows of alternating black and gray streaks or spots: others are of black layers interlaminated with gray dull-lustrous material, in which latter material a macrospore occasionally peeps out. There are numerous laminæ wholly made up of flattened fibrous tubes, filled with as well as surrounded by gray granular material; the aspect of lines, etc., differing

in all these cases with the fracture of the specimen, its obliquity and so on. Another lamina will show a somewhat open cellular upper and lower rind with a dense black central plate. Still another may consist of connected patches or expansion-like processes on either surface of a ? blade or ? midrib-like center. Then we have them apparently composed entirely of one kind of cell:—of rows or a cluster of seed-cases attached or detached from stalk-like connections:—masses of cells gray in color, apparently perforated in a regular manner, by holes. And this necessarily crude list might be lengthened, making it evident that if future investigation shall show that none of the structures observed are new to coal—or to known coal-plant anatomy, these laminæ cannot in future be said to be so devoid of internal organization as to prevent identification being some day possible.

5. Indications of internal organization of plants in and composed of coaly material are, in suitable specimens and where favorable conditions obtain, more or less distinctly imprinted upon the surfaces of those scales or thin plates of calcareous material (selenite and gypsum) filling or partially filling otherwise open cracks in coal. Not only is the lamination or grain of coal clearly portrayed upon this whitish scale, but otherwise invisible plant-structures occupying the pitch-coal layers, are rendered evident. In these natural micro-lithographs, as I propose to call them, we find that it is the gray or paler colored part of the fossil which has made its impress in blackish "ink" upon the crystalline lime, while the black portion does not appear to have been affected. Here then we have a clear instance of the affinity of the mineralized hydrocarbonaceous material, occupying the cells of coal-plants, for the lime in the cracks in the coal-beds: the lime would seem to have *drawn* the carbon compound out of the coal, because in some cases small cavities may be detected in the face of the coal exactly corresponding to the black markings or carbon prints adhering to the scales when removed. For the most part these lime-filled cracks are associated with the pitch-coal layers, and avoid the coarser, duller ones: in short, the more pronounced the pitch-coal laminæ and the thinner the layers of coal matrix, the stronger the scales of lime. "Bird-eye" or "Button-spotted" fractured coal yields these tiny

lithographs of the coal-period, perhaps in better condition than any other.

6. Another method which I have experimented with in order to test pitch-coal laminæ for masked anatomical structure, is polishing. But while a finished polished surface may reveal nothing of this a subsequent rubbing on soft leather, until quite warm, will sometimes reveal decided indications of structures. The result of this frictional heat produced upon the leather (the sheep-skin covers of a quarto volume, in my case), seems to contract the denser and blacker areas, and to elevate the material now occupying the cells or tubulous parts: at any rate the result is an uneven surface, which, when viewed in a favorable light, shows differences or markings pertaining to original vegetable tissues. I submitted drawings made from a specimen thus treated (a bit of one of the black, brittle laminæ out of the "Pittsburg" seam in Pa.) to Dr. David White of Washington, D. C., who showed them to Prof. F. H. Knowlton, and I am indebted to them for the remark that the markings could not be those referable to wood, but might possibly be *thallophytic*. It is interesting to observe in connection with this method of finishing polished specimens of coal, that (in the case of bituminous coal at all events) where the above mentioned etched surface is produced,—all the bright lustrous, pitch-coal lines or laminæ become depressed below the surface of the intervening or cementing-matrix material; the latter always standing out in relief as it appears in contrast with the enclosed shining coal. I am myself not certain as to exactly how the irregular surface thus created comes about; possibly there is a shrinkage produced in one material and a swelling in the other; or the pitch-coal may remain *in statu quo*, while the duller matrix swells. Anyhow the leather-rubbing process does not seem to *remove* any material, but merely acts upon the already smooth and even surface, through the medium of heat, so as to produce an uneven surface. What the temperature rises to when the rubbing is sufficient I cannot say, but it is probably about 110° F. On cooling to normal temperature the effect is *not* destroyed.

Another and rather instructive side-light upon coal-formation comes from the interiors of the so-called "sulphur balls" of the miner. Favorable specimens of these balls, which con-

sist of ironpyrites, lime, quartz (chalcedonic quartz I believe), with more or less brown and black carbonaceous material, on careful splitting and breaking up show very considerable quantities and variations of plant tissues, besides leaves, fruits and seeds. These balls, when less metalliferous and more carbonaceous, have yielded marine shells. The loose, uncompressed condition of most of these vegetable remains, changes from coaly material into almost purely inorganic masses, clearly testifying to the *condition of the vegetable matter of the coal-beds* containing those nodules *after burial and subsidence:* in other words, these balls of lime, silica and iron are silent witnesses to the fact that the original thickness of the coal-seam was not materially different from its present thickness; for these balls are pseudomorphs, so to speak, in the sense that the fixed carbon and hydrocarbonaceous substances of the original vegetable débris, have been dissolved out and their places slowly taken by inorganic or metallic substances, which gradually crystallized and became a comparatively compact, hard rock. That a further study of these concretionary masses must be productive of valuable results in this connection goes without saying. My most instructive specimens have come from coal in Iowa; and out of these, by grinding, wetting and polishing, the best plant tissues found in them have been brought into view. Binney, it will be remembered, nearly half a century ago in England, sliced somewhat similar, but much more calcareous masses from the coal; and the inferences then drawn were that coal was largely composed of plant remains the same as those seen in the nodules.

With reference to the formation of the thin strata of shale, so characteristic of the great "Pittsburg" coal-bed, some account of which will be found in this magazine (vol. XIV., 1897, p 356); it has since occurred to me that on the supposition that the vegetable matter of which much of this seam is composed were drifted into position from off the land where it grew, and if we are to accept the dictum of writers who say that when decayed vegetable matter is mixed with fine earthy matter and is carried down and comes to rest in large areas of water, the vegetable detritus sinks first, then if each separate bench or layer of this bed of coal represents (so far as its terranean vegetable constituents go,) water-transported materials, may

not each individual layer or band of shale represent the earthy matter carried with the vegetation into the lake or sea, but which became disengaged from the latter by reason of its capacity for remaining longest in suspension in the water? If this be a true explanation of the phenomenon of these thin sheets of mud, there is some reason for supposing that these mud-layers were really "old soils" in which the coal plants grew. But in this case if the above mentioned mode of their deposition is accepted, we have the "old soils" *on top* of the plant-remains they produced; and yet only "soils" in the sense that their ingredients formerly existed as soil upon the surface far away from their present resting place. Of course this hypothesis does not deny the existence of aquatic plants (algæ, etc.,) in the lake or sea. It does seem to demand periodic floods, otherwise why not an unbroken flow or transportation of vegetable remains? It cannot, I think, be denied that this idea of the origin of the slaty layers in the coal furnishes a very satisfactory explanation of all the more important physical, stratigraphical and paleontological conditions, contents and aspects of the "Pittsburg" seam, which may be summarized thus:

1. Stratification. 2. Lamination. 3. Marked alternations of vegetable with mineral sediments, etc. 4. Uniformity of thickness of every individual layer, bed, or stratum. (Local irregularities of deposition proving the rule.) 5. Transported foreign pebbles or boulders. 6. Absence of *Stigmaria*. 7. Fish, mollusks, crustaceans, etc. 8. Vast areal extent covered by existing layers, (to say nothing of the probable original area involved). 9. The common mingling-ground or resting-place for vegetable remains of land and water forms, no matter how large or how small, from trunks of trees to pollen grains. 10. Agrees with the idea or theory of gentle and uniform subsidence over the whole coal-forming expanse, as opposed to that requiring repeated elevations followed by subsidences—the see-saw theory. 11. The existence of myriads of micro-organisms working molecular and chemical changes in the vegetable products and residues. 12. Ash of coal.

If we do not regard the phenomena of this coal-bed in the light of the above suggestions, we come back again to the old

perplexing question—what are these interstratified sheets of clayey material in the coal, and how did they get there?

9. Clearly, then, the coal is still full of objects of the greatest interest to the patient observer and investigator, and if the foregoing facts and suggestions have no more effect upon the question of coal-formation, than a *reminder* that there are different ways of looking at and into the subject, this communication will not have been prepared in vain.

Mischief has been done in the past, and but little benefit to science can come in the future, from making isolated facts basis for generalizations. Remember too, that it is so long ago since the coal-period, that the greatest caution is necessary in attempting to draw conclusions from facts. Leave deductions for future generations. Avoid "must be's." Experiment, observe, record phenomena.

Explanation of Plate II.

Fig. 1. A variety of "Rods" in situ in a bit of "Pittsburg" coal: the upper rod contains spindle-shaped beads of milk-white substance; and a clear, pale, yellowish material (?ambrite) fills the cavities of the lowest rod on left. Magnified about 25 diameters.

Fig. 2. The aspect of the cells surrounding some of these rods. × 150.

Fig. 3. Transverse section of a rod surrounded by cells. From Penna. Anthracite. × 60.

Fig. 4. Longitudinal section (somewhat oblique) of "tubes," composed of thick-walled fibres or bundles having gray cellular centres, and surrounded by gray cellular tissue. From Lehigh anthracite, Penna. × 15.

Fig. 5. Oblique section of tubes and matrix of fig. 4. From Lehigh Anthracite, Penna. × 15.

Fig. 6. Transverse section of tubes and intertubular material, with portion of the epidermis (?) of the plant.

Fig. 7. Transverse section of one of the same tubes. × 50.

Figs. 8, 9 and 10. Structural markings developed by polishing one horizontal surface and two sides (at right angles to one another) of a fragment of a bright pitch-coal lamina from the "Pittsburg" coal bed. × 300.

Fig. 11. Structural markings upon the vertical face of a thin scale of selenite occupying a crack in a pitch-coal lamina in the "Pittsburg" coal. (Hydrocarbonaceous material has imprinted itself upon the scale of lime in such a way as to make a "nature print" of the vegetable structures contained in the coal.) × 200.

Fig. 12. Portion of several rows of (?) vegetable cellular structures

observed imbedded in clear, compact, anthracite from the Lehigh region, Pa. × 70.

Fig. 13. Part of a patch or cluster of seed-like bodies (apparently in situ), and associated with more or less solid black laminæ in anthracite. × 5.

THE ICE-CONTACT IN THE CLASSIFICATION OF GLACIAL DEPOSITS.

By J. B. Woodworth, Cambridge, Mass.

Several modes of classifying the glacial deposits have been put forward within recent years, all tending to closer discrimination in regard to the form, structure, and names of these deposits and all embodying the theoretical principle of genesis. The most notable of these classifications are the comprehensive categories of drift made out by professor Chamberlin* and the tabulation of glacial effects from a geographical point of view by Mr. McGee.†

In devising a genetic classification of glacial deposits, everything depends upon determining the geographic and physical relations of the products of change to the agencies which produced them. Of these agencies, there are two, the ice and the water produced by the melting of the ice or coming into the field of glacial action in the form of rain. From observation of existing glaciers we learn to attribute the massive, unstratified deposits to the direct action of the ice, the stratified and assorted drift to the action of water coming from the ice. From the structure and form of deposits of till and stratified drift we arrive at conclusions with regard to the position of the materials held in relation to a vanished glacier; as to whether the deposition took place inside or outside of the field of ice action, hence intraglacial and extraglacial deposits; whether, in the former case, the deposits had their characteristics determined on the ice, in it, or under it upon the ground

*T. C. Chamberlin: La classification des depôts pleistocenes, 5me Session, Congrès Geologique Internationale, Washington, 1891, pp. 176-192.

†W J McGee: The classification of geographic-forms by genesis, Nat. Geog. Mag., i. 1889, p. 36. Pleistocene History of Northeastern Iowa, 11th Annual Report, U. S. Geol. Surv., pt. i. 1891, p. 256.

over which the ice-sheet moved, hence, superglacial, englacial, and subglacial categories of both stratified and unstratified drift.

The criteria for the simpler determinations of the place held in relation to the ice naturally followed the recognition of the more general ear-marks by which it was shown that the drift was of glacial origin. The till associated with striated rock surfaces was first recognized as of glacial origin, while for a long time afterwards the water-laid drift continued to be regarded as some form of marine, or, at least, non-glacial deposit. In fact, the glacial gravels and sands were so far separated in theory from the influence of ice-sheets as to be denominated "modified drift," and the peculiar forms taken on in eskers and kames were attributed to the action of waves and currents in modifying the till during a time of submergence of the land. As yet it had not been seen that these water-worn deposits exhibit in their topography and arrangement evidence of the former presence of ice quite as convincing as that arising from the association of striated rock surfaces and fragments with the till group, evidence which we find in the kettle-holes and steep, often kame-like banks of ponds and terraces.

The recognition and application of this evidence of the deposition of sands and gravels about or upon masses of ice, either the ice-sheet itself or outliers of it, have been slowly brought about. It is difficult to say to whom the credit is due of first pointing out the evidence. The application was first made upon two groups of phenomena, the esker ridges, the kame-kettles and ponds; later it was used in the diagnosis of the glacial sand-plains. N. H. Winchell, Upham, G. F. Wright, and perhaps the Scandinavian geologists appear to have been the pioneers in regarding the water-laid deposits as reflecting the limits placed upon the distribution of the detritus by walls of ice. The principles first appear with a distinct enunciation in the writings of Gilbert* on the differentiation of the moraine terrace, a geographic form in which slopes due to the deposition of debris by ice and water against the edge of a glacier were

*Monograph i., U. S. Geological Survey, 1890, pp. 81-83.

recognized and criteria presented for distinguishing terraces of this origin from the slopes of beaches, fault-scarps, and river cut terraces. Davis* next applied the method to the delimitation of the small esker-fan in Newtonville, Mass. In all this work, the essential thing is the recognition of a topographic feature which marks the former contact of the gravels and sands with now vanished masses of ice.

In a physical sense, we may speak of that feature in the topography of the glacial gravels which delimits or outlines vanished masses of ice as the ice-contact. The ice-contact is, in its most typical form, an even slope, with materials at or near the angle of repose. In this shape, it is frequently seen flanking one or both sides of an esker, the heads of sand-plains and the sides of many glacial lakelets or kettle-holes.† The ice-contact may arise in the unstratified group, as on the inner edge of boulder-belts;‡ and the inner slope of frontal moraines is, almost without exception, where the ice has retreated from them, an ice-contact.

The evenness of slope of the ice-contact may be perturbed by irregularities in the wall of the ice against which deposition takes places, as by the presence of water-worn marginal crevasses and tunnels; or by the slope of the ice-front so that deposition overlaps the edge of the ice. When such an ice-front melts out, the ice-contact will reflect the conditions of deposition of the detritus, in hummocky or kame-like slopes whose general declivity may be much less than that of the talus. Projecting, esker-like masses of gravel may be traced into the ice-field, and in the case of thick water-laid deposits the head of the sand-plain may break down into a typical kame belt.

Where the edge of the ice-sheet is deeply channeled, as seems to have been the case in the last glacial epoch in New England, there is often a wide field in which gravels and sands were sheeted over the attenuated edge of the ice or about ice masses of unequal elevation, so that the ice contact is no longer a line on the map but must be represented as splitting with an inner edge on the iceward side of the kame belt or

*Bull. Geol. Soc. Am., Vol. i, 1890, pp. 195-202.

†Warren Upham: Walden, Cochituate, and other lakes inclosed by modified drift, Proc. Boston Soc. Nat. Hist., xxv, 1891, 228-242.

‡J. B. Woodworth and C. F. Marbut: The Queen's River Moraine in Rhode Island, Journal of Geology (Chicago), iv, 1896, 698.

kame field, and an outer edge at the head of the sand-plain, if that has not entirely broken down into kames.

In the case of the water-laid drift, the ice-contact is further marked by textural, structural, and topographic features of a minor sort. As to texture, the fragments composing the detritus are invariably coarser in the contact zone than outward in the body of the sand-plains or terraces, because the currents issuing from the ice diminish as the distance increases from the ice-contact. Boulders and even patches of till are not infrequent exhibitions in the contact zone because of the deposition from moving ice. As for structure, the fore-set and top-set beds of sand-plains, as shown by professor Davis, spring out abruptly from this zone and decline, the one steeply, the other gently, towards the outer limits of construction. There is, even where the back-set beds have not been observed, a thin talus deposit frequently showing the sliding down of the materials after the melting out of the ice. As for the associated topographic features, the ice-contact flanks the highest part of the sand-plain and the lateral terrace, except where the latter has been built out from the valley wall toward the ice or by lateral drainage indifferent to its banks.

The importance of recognizing and using the ice-contact in unravelling the history, relations, and genesis of the water-laid glacial deposits cannot be too much insisted upon. Practically all the advance which has been made in the last ten years in the understanding of the stratified drift has come about through the tracing of this feature, as is witnessed by the work of Salisbury in New Jersey, Willis in Oregon, and numerous other workers in America alone. Without the recognition of the ice-contact, expressed or implied in the interpretation of topographic form, the long, open hollows of a plain, as that of New Haven, remain to be explained as depressions kept open by violent eddies in powerful floods of water, sweeping, in this instance, down the lower Connecticut valley long after the ice had disappeared from the vicinity. Viewed in the new light, the sands and gravels of this valley, instead of being deposits formed long after the ice-sheet retreated to the mountain valleys of the upper Connecticut, are seen as accumulations making in the presence of lingering masses of the ice, a view which breaks down much of the

distinction between the Champlain epoch so-called and the Glacial epoch proper, so far as that is marked by the last till deposits.

There are many deposits of the stratified group which are not yet fully understood. The first question which arises is, was a given deposit made inside or outside of the ice? The presence of distinctive ice-contact phenomena gives us the answer. The kame group still presents more difficulty than any other class of glacial deposits. The most general statement which can be given of the group is that kame topography indicates deposition of the materials in the presence of ice. Certain kames are gravitatively rearranged, apparently superglacial extensions of the sand-plain group, others are similarly altered forms of lateral terraces, yet others are aborted eskers. But the stratified group as a whole now presents an array of phenomena quite as explicable on the glacier hypothesis, to the exclusion of other known causes, as the first and once better understood till group.

The ice-contact, which has furnished such important help in placing drift deposits, finds its expression in the classification in other terms, those which divide the deposits into categories of drift laid down inside the ice or outside of it, or in general in those terms which express place relations to the ice. And since these place relations are everywhere implied in the current classification of the phenomena of glacial deposits, there can be nothing novel in a system in which the ice-contact is made one of the means of subdivision. The accompanying table has been drawn up with the ice-contact in mind.

The introduction of a few little used terms demands an explanation if not an apology. Practically all forms of ice-laid drift may be spoken of as till, which has a wider meaning than boulder-clay since some tills are sandy rather than clayey. A correlative term for the stratified drift, though much wanted, has not been brought into our language. The English geologists have occasionally employed the term "kame group," but this has not found favor because it is misleading, particularly at the present day when the word *kame* has a more restricted meaning than formerly, if indeed it has a definite

CLASSIFICATION OF GLACIAL DEPOSITS.

CONSTRUCTIONAL PRODUCTS OF GLACIATION.	A. ICE-LAID DRIFT. (*Till group.*)	Intraglacial Till. (*laid down in the field covered by the ice of a given stage of development.*)	Superglacial:	Lateral, medial, marginal moraines of cliff-debris. Ablation deposits, wind deposits. Rock-tables.
			Englacial:	Dirt-bands, crevasse drift; from various sources.
			Subglacial:	Ground moraine, till plains, boulder-trains. Submarginal moraines, drumlins, crag-tails. Dislocated terranes. (e. g. Rügen).
		Extraglacial Till. (*laid down in the field in front of or beyond the ice of a given stage of development.*)	Ice-bound: (*in contact with the ice edge or supported by it*).	Frontal, terminal; dump, push moraines, lobate or interlobate. Boulder-belts.
			Ice-free: (*beyond and below the ice edge or base*).	Berg-till; erratic blocks and deposits of glacial origin, ice-rafted and dropped on the bottom of lakes and seas.
	B. WATER-LAID DRIFT. (*Wash group.*)	Intraglacial Wash.	Superglacial:	Some kames and possibly certain eskers belong here.
			Englacial:	Some kames and possibly certain eskers belong here.
			Subglacial: (*under the ice or on the ground*).	Many eskers conceded to belong here. Paha. Kames, in part.
		Extraglacial Wash.	Ice-bound: (*in contact with the ice edge or supported by it*).	Glacial sand-plains, outwash plains, esker-fans; some kame, or pitted-plains. Laterel terraces, lateral moraine terraces, kame-terraces.
			Ice-free: (*beyond and below the ice edge or base*).	Valley-trains and plains of sand and gravel deposited beyond the ice-sheet or glacier and below the level of its base. River terraces; silt-plains; clays, fluvial, lacustrine, marine. Lake beaches.

meaning at all. The term wash here used is simply intended to fill the gap until a better word is found. By *ice-bound* is meant, in the case of both till and wash, that condition of a deposit in which it is laid down at the ice edge in such a way as to retain, when the ice vanishes, some trace of the ice-contact which once existed. By ice-free is meant that group of deposits which, though of glacial origin, are deposited beyond the influence of the ice. In the case of the till, the sole means of attaining this state is through the rafting of the debris. Where stratification in this case intervenes, on the dropping of the materials, the ice-laid distinction ceases to hold and the deposit passes into the water-laid group. Of the water-laid deposits, such accumulations as are laid down in river valleys at levels below the base of the ice may be said to be *ice-free*. Just as soon, however, as the construction of sand-plains or deltas reaches up to the ice edge and begins to bank and gravel against that edge, the deposits become *ice-bound;* they will show the ice-contact upon the liquefaction or retreat of the glacier A classification on this basis cannot supercede the admirable grouping presented by professor Chamberlin, to which reference has already been made: it is simply another way of pigeon-holing the same series of phenomena.

ELEVENTH WINTER MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA.

Reported by E. O. Hovey, New York.

Although the first meeting of the Geological Society of America took place eleven years ago in Ithaca, it was merely one of organization, so that the meeting which was held at Columbia University, from the 28th to the 30th of December, 1898, really rounded out the first decade of active life and work of the society and marked an epoch in its history. The report of the council showed that the society had had a very prosperous year, and it reviewed in brief measure the history of the decade. In the words of the introduction to the report: The society has united the geologists of the continent, produced harmony of feeling, thought, and labor, created and cemented

friendships, and prevented the geology of America from becoming provincial. It has stimulated research and publication, and has placed on record a great body of knowledge. The avowed purpose of the society, "The promotion of the science of geology in North America," has been carried out, and already the society's bulletin has given it a prominent place among the older geological societies of the world. The society began with 112 "original" fellows, and now numbers 237 in active membership. Five years ago the society had secured the adhesion of nearly all the active geologists of the continent, and since that time the membership has remained practically uniform, the losses being balanced by the elections. The geographical distribution of the present fellowship is very wide, thirty-five states and territories being represented besides the District of Columbia, Canada, Mexico and Brazil. Thirty-seven members live in the District of Columbia, twenty-nine in the state of New York, twenty in Canada, nineteen in Massachusetts, fifteen in Pennsylvania, eleven in Illinois, and ten in California.

After the address of welcome, delivered by president Low, of Columbia, the necrology of the year was read, which consisted of a memorial of professor James Hall by professor John J. Stevenson, of New York University. With the hand of a life-long friend the speaker briefly sketched an outline of the life of the celebrated scientist to whose labors, carried on for more than sixty years, the State of New York owes more than its citizens appreciate. He told how young Hall spent his early boyhood and youth at Hingham, Mass., with very limited educational advantages; of his early love for natural science, as evidenced by his walking from Hingham to Boston and back, a distance of twenty-five miles, to attend each of the lectures delivered at the Lowell Institute by the elder Silliman; and of his struggles and success at the Rensselaer Polytechnic Institute at Troy, where he came under the influence and instruction of that pioneer geologist, Amos Eaton. After his graduation Hall was packing his few earthly possessions preparatory to going he knew not where, when Eaton offered him a position as librarian of the Institute, thus, probably, saving him to the scientific world. Hall accepted the place, though it barely gave him subsistance, because it would enable him

to carry on the geological work on the strata of New York which he had already begun, and would also allow him to continue his studies under Prof. Eaton. When the first geological survey of the state of New York was organized in 1836, he was appointed assistant to Dr. Emmons and from that time to the day of his death Prof. Hall was connected with the institution whenever it was in existence. Much of the time he was the whole survey corps, himself, and he expended largely of his private means to carry it on, when other resources failed him. Prof. Stevenson rapidly passed in review Hall's connection with geological work in New York state, Illinois, Iowa and Wisconsin, and on material brought home by several government expeditions, as well as by those which he himself had sent out into what was then the great West. The speaker paid high tribute to Prof. Hall's acuteness of perception, ability to stimulate others to work, pertinacity of purpose, frankness of character and the steadfastness of his friendships in spite of many sharp contests.

Prof. Stevenson's presidential address was entitled "Our Society," and gave a concise history of geological societies in America and showed the necessity for their existence and their value to the scientific and general public. In abstract it was as follows:

Several travelers of the eighteenth century, among them especially Guettard, Alexander, and Schoepf, gave more or less important information respecting the geological structure and mineral resources of our country, but geological work, properly so called, began only with McClure's studies in 1806. The publication of his results, presented to the American Philosophical Society of Philadelphia, on January 20, 1809, led others to make studies, and soon afterward there appeared numerous papers dealing with geological subjects. By 1820 the students of geology had become so numerous that the American Geological Society was organized in New Haven, Conn., where meetings were held certainly until the end of 1828. Before another decade had passed there were groups of geologists in New England, New York, and Pennsylvania, while Olmstead and Vanuxem had made preliminary surveys in North Carolina and South Carolina, Troost had begun the survey of Tennessee and Hitchcock that of Massachusetts. In 1832 the Pennsylvania geologists, feeling much in need of an official survey of their State, organized the Geological Society of Pennsylvania to arouse public interest and thus attain the desired result. The volume of their publications contains papers which attack geological and economic problems of the first

order, and their investigations were not confined to the state of Pennsylvania. Geology, however, was becoming too broad in its scope and its workers too numerous to be embraced by a local society, even though the list of correspondents was as large as that of the active members. In the Appalachian region of Massachusetts, New York, Pennsylvania, and Virginia serious problems were encountered which could not be solved within the boundaries of a single state, and a right understanding of the work done in one state was necessary to the correct understanding of the work done in the adjoining state. Correspondence proved a failure, incidental or casual talks led to misunderstandings, systematic conference was necessary, with a generous contribution by each of his knowledge to the other.

On April 2, 1840, as the result of a conference held in Albany in 1839, eighteen geologists met at the Franklin Institute, Philadelphia, and organized the Association of American Geologists, with Prof. Edward Hitchcock as chairman. Those present were the state geologist of Massachusetts, six geologists of the New York survey, six of the Pennsylvania survey, two of the Michigan survey, and three not connected with any public work. Mr. Martin H. Boye is the only survivor of the eighteen. The succeeding meetings in Philadelphia and Boston were attended by many geologists, of whom only Boye, O. P. Hubbard, and J. P. Lesley remain. A volume of the Association's proceedings published in 1843 contains several papers which made a deep impression on American geology. Here are the five great memoirs on Appalachian conditions by the Rogers brothers, Hall's noteworthy discussion of the Mississippi basin section, Hitchcock's elaborate discussion of the Drift, and many contributions by other members. Prof. Hall said on one occasion that the inspiriting effect of these meetings could not be overestimated. As one of the youngest members, he was impressed by the mental power of those great men, all untrained in geology, except Taylor, whose education under William Smith, proved advantageous in many ways, but very disadvantageous in others, as it had provided him with a generous stock of well set opinions. Though wholly self-taught, working in a country sparsely settled, without borings, without railroad cuts, oil borings, mine shafts, or any other of the advantages so necessary to us, those men elaborated systems, made broad generalizations, learned much regarding the succession of life, and discovered the keys which were, in later years, to open mysterious recesses in European geology. The advantages of the union and personal contact were so manifest that the following year (1841) the naturalists applied for and gained admission to the association.

In 1842 the first series of geological surveys practically came to an end and the geologists were scattered, many of the younger men being compelled to enter other callings. The Association of Geologists and Naturalists held its meetings regularly, but its strength diminished and, in 1848, it yielded to outside pressure, and became merged into the American Association for the Advancement of

Science, which threw its doors wide open to all entertaining an interest in any branch of science. The first meeting of the new organization had a roll of 461 members. Comparatively little was done in geological work between 1842 and the close of the civil war.

The rapid development of the country's internal resources during the war and the attendant growth in manufacturing interests made necessary increased efficiency in scientific training, and enormous gifts were made to our leading institutions for that purpose. The importance of geological knowledge had become very evident during the development of iron, coal, and oil resources, and the geologist found himself suddenly elevated from a place surrounded by suspicion to a post of honor. Several government expeditions were sent into the little known country west of the one hundredth meridian, each of which was accompanied by a geologist or a physician who understood something about geology. Within a decade after the close of the war, state surveys were undertaken in New Hampshire, New Jersey, Pennsylvania, Ohio, Indiana, Kentucky, Michigan, Wisconsin, Minnesota, Iowa, Missouri, and other states, while the Canadian survey, which had gone on uninterruptedly since the early forties, was made more extended in character.

The conditions which rendered imperative an association of geologists in 1840 were the present conditions in 1880, only more oppressive. The problems of 1840 were chiefly those of a narrow strip within the Appalachian area; those of 1880 concerned the whole continent. Geologists were increasing in numbers, but opportunities for making personal acquaintances were few; meetings of societies in midsummer could be attended only by those who were not connected with official surveys or who were detached for office work. Workers were gathering into little groups on geographical lines and there was danger that our geology would become provincialized. In 1881 the tension was such that several geologists connected with official surveys urged the formation of a geological society to bring about closer bonds among geologists, and they succeeded at the meeting of the American Association of that year in securing the appointment of a committee to consider the matter. This committee was not able to accomplish anything very definite, however, until 1888, in connection with the Cleveland meeting of the American Association for the Advancement of Science. Then, under the guidance of a committee of organization, consisting of Profs. A. Winchell, J. J. Stevenson, C. H. Hitchcock, John R. Procter and Edward Orton, a provisional constitution was adopted making the original membership of the new society rest upon membership in Section E (Geology and Geography) of the Association, thus avoiding a split with the parent society. Happily the high dues and a general belief that no society could be formed on the proposed basis kept the list of original fellows from being swollen by those whose relations to geology began and ended with attendance upon the American Association's meetings. Permanent organization was effected during the

holidays of that year by the election of Prof. James Hall as president, and Profs. James D. Dana and Alexander Winchell as vice presidents, and the new society was fairly launched on the career which has amply justified its existence.

One great object of the society is publication; hence the choice of first editor was very important. Dr. W. J. McGee was selected for the office, and through his skill, care, and determination, the Bulletin at once took front rank among scientific publications, a position which it has always maintained. As a storehouse of fact and of broad, just generalization, the volumes of the society's bulletin are excelled by those of no similar publication.

Fears and misgivings abounded when it was discovered that this society was a success from the start. The American Association for the Advancement of Science had been the one society for so many years that attempts at differentiation seemed to be efforts to cut away the pillars of scientific order, but the fears were merely nightmare, and our society has proved itself an efficient ally of the Association. The society closes its first decade justly gratified by success and full of hope for the future. American geologists are no longer a disorderly lot of irregulars marching in awkward squads, but they form a reasonably compact body, though as individuals they owe allegiance to Canada, the United States, Mexico, or Brazil.

But this society has to do with the world outside of itself and outside of its immediate line of thought. It must have more to do with that world in the future, if the outcome for science is to be what it should be, for the time is approaching rapidly when we must seek large sums for aid in prosecuting our work. In a proper sense this is a utilitarian age. Everywhere the feeling grows that the earth is for man, for the rich and the poor alike; that those things only are good which benefit mankind by elevating the mental or physical conditions. There appears at first glance to be very little connection between great manufacturing interests on one hand and stone pecking at the roadside or the counting of striæ on a fossil on the other, yet a geologist rarely publishes the results of a vacation study without enabling somebody else to improve his condition thereby. The speaker then went on to relate several instances showing the intimate connection between geological studies and the proper development of the economic resources of the country. Among the striking instances cited were the discovery of the importance of the coal fields of Maryland, the determination of the absence of coal strata in New York state, that of the value of the salt lands in Michigan, and the announcement of the occurrence of vast bodies of iron ore in the Lake Superior region.

The Mesabi and Vermillion ranges of Minnesota contain deposits of iron ore, which for the present, at least, appear to be even more important than those of Northern Michigan. Almost fifty years ago, J. G. Norwood, while studying the easterly end of the region discovered the Mesabi ores; a few years later, Whittlesey, after a de-

tailed examination further west, predicted the discovery of similar ores, a discovery actually made in 1866, by Eames, who was then state geologist, and engaged in studying the Vermilion range. Though not utilized at once, these announcements were not forgotten and systematic exploration was begun in 1875, when the need of high grade ores at low prices made necessary the opening of new areas. Almost at once, the state geological survey determined the extent of the ore-bearing region, differentiated the deposits and removed erroneous impressions respecting the extent and distribution of the ores. The effect of these discussions and of the positive fixing of areas has been to increase development and to cheapen ores of the best quality so far that Bessemer steel can be manufactured more cheaply in the United States than elsewhere, in spite of the fact that wages are still higher, not simply numerically, but in purchasing power, than in any other iron-producing country. An examination of the reports which have brought about this result compels one to say that the anxiety for economic results does not appear to have been an impelling motive during the work. There were perplexing geological problems to be worked out and the solutions could be discovered only by the most painstaking work. This investigation led to the economic results and experience has shown over and over again, the value to the several states and to the nation at large arising from geological surveys carried on by trained scientists.

Aside from the two papers already noted there were forty-six communications laid before the society, of which number thirty-five were read. The first paper read was by W. O. Crosby, of the Massachusetts Institute of Technology, and was entitled, "The Archean-Potsdam Contact in the Vicinity of Manitou, Colorado." By means of photographs and diagrams the author showed the remarkably plane character of the contact of the Archean granite and the Potsdam sandstone, which is in striking contrast with the existing topography of the granite even in coastal regions.

The paper distinguished and described in detail with numerous illustrations the original and secondary irregularities of the contact, the latter including a few flexures and numerous small faults which throw important light upon the origin of the sandstone dikes of the Manitou district. The original irregularities of the contact are all small, and, as a rule, evidently related to the occurrence in the Archean granite of a coarse concentric or spheroidal structure. The general conclusion of the paper was that the Archean land surface must have passed with extreme slowness beneath the waves of the Potsdam sea.

"*Outline of the geology of Hudson Bay and Strait,*" by ROBERT BELL of the Canadian geological survey. The author considers Hud-

son's bay as an inland sea rather than a bay. It is about 1,000 miles long by about 600 miles in extreme width, but its greatest depth is only about seventy fathoms, while the depth of Hudson's Strait reaches 300 fathoms. The text books of geology represent the Archean nucleus of the continent as embracing Hudson's bay within the arms of its V-shaped area, but the actual structure of the region is not as simple as the books would seem to indicate. While Laurentian rocks border the bay on the east and part of the west sides and Huronian beds form the shore at the northwest, the southern shore of the bay and the western shore of James bay are occupied by strata ranging in age from Cambrian to Devonian. Considerable gold seems to exist in the iron pyrites in the Huronian rocks of the northwestern portion of the region, and has also been reported from quartz veins of the same region. The deposits of iron ore, furthermore, are very rich. Middle Silurian rocks occur on the east, west and north sides of the bay and in Baffin land. The Devonian area southwest of James bay is very large and rocks of the same age are known to occur on Southampton island. No good coal has been found anywhere in the region, though poor material occurs. Even in Devonian times the seas were independent of the Ontarian Devonian and supported a distinct fauna. The whole surface of the rock is glaciated, and in such a way as to indicate the probability that the ice came from Labrador. Remains of the mammoth (Elephas columbi) have been found on Long island at the entrance to James bay, and those of the mastodon near York Factory on the main bay.

Henry B. Kümmel, of Chicago, Ill., in a paper entitled "The Newark System in New York and New Jersey," stated that the rocks form a northwestward dipping monocline, interrupted by gentle folds and many faults, two of which have a throw of several thousand feet. The character of the rocks varies greatly, so that subdivisions established in one area do not hold for the entire field, and yet subdivisions based on lithological characteristics are the only ones possible. Both extrusive and intrusive trap sheets occur, and their relations to the sedimentary beds are instructive. The question of thickness is complicated by the faulting, and estimates vary from 12,000 to 15,000 feet. The strata were probably accumulated under estuarine conditions in shallow water. The surrounding land areas seem to have been reduced near base level and deeply covered with residuary materials immediately preceding the deposition of each bed, but during their deposition subsidence of the estuary and elevations of the surrounding areas were in progress.

N. H. Darton, of the U. S. Geological Survey, gave four papers on features of geology of the Black Hills, which were illustrated by lantern slides and were in brief as follows:

Discovery of Fossil Fish in the Jurassic of the Black Hills. These fish were found in a sandstone very near the base of the Jurassic which lies unconformably on the Red beds of supposed Triassic age. The locality was Hot Springs, South Dakota.

"*Mesozoic Stratigraphy in Southwestern Black Hills.*" This paper was an account of preliminary studies made during the summer of 1898. A detailed account was given of the relations and variations of the Mesozoic members. An announcement was made of the discovery of fossil bones, mainly of very large size, from the Cycad horizon in the lower Cretaceous and of an interesting limestone a short distance higher in the series. The marine Jurassic was found to be abundantly fossiliferous in the area studied. Much new light was obtained in regard to the stratigraphy of the Benton, Niobrara and Pierre formations, and there was discovered in the latter a "Teepee zone" due to calcareous lenses filled with Lucina occidentalis, similar to the one described by Gilbert in southeastern Colorado. Mention was also made of the discovery of fossils in the Purple limestone and in the top of the Minnelusa formation.

"*Relations of Tertiary Formations in the Western Nebraska Region.*" This paper set forth the result of observations made in 1896 and 1897. In the western Nebraska region there was found an extension of the White River series comprising the Titanotherium sands, to which the name Chadron has been applied, and a series of pink clays, designated the Brulé formation, which comprises the upper members of the White River series, and probably some additional beds discovered in the highlands south of White river. Next above and separated by a marked unconformity is a series of sand and sandstones called the Gering formation. This is overlain by the "Loup Fork" which has been found to comprise a lower member, called the Arikaree formation in the Pine Ridge region, overlapped to the southward by a considerably younger member, called the Ogallala formation, which extends into Kansas and southward as "Tertiary grit" or "mortar beds." The Arikaree and Ogallala formations are separated by a strong unconformity, with shore deposits. The observations were extended northward into the Big Bad Land region in order to give a definite basis to the correlation.

"*Shore Line of Tertiary Lakes on the Slopes of the Black Hills.*" These shore lines were found to extend far up the slopes of the central region of the Black hills. Extensive areas were also discovered of the Tertiary formations containing typical mammalian remains of the White River series. In a portion of the area the formations are overlain by extensive deposits of Pleistocene sands and gravels. From the relations and slopes of the shore lines and formations it will be practicable to trace out several stages in the uplift and topographic development of the Black hills.

"*The Geology and Physiography of the Lake Region in Central America,*" by WILLARD HAYES, of the U. S. Geological Survey. The region described includes southern Nicaragua and northern Costa Rica, extending from 10° 30′ to 12° 30′ north latitude and from the Caribbean to the Pacific. It includes the route of the projected

Nicaragua canal and the largest lakes of the western hemisphere south of the glaciated region of North America.

The region is characterized by two types of topography, viz: the recent volcanic mountains and plateaus in which the original constructional forms are more or less perfectly preserved and the areas of Tertiary igneous and sedimentary rocks in which the forms are due to long continued subaërial erosion. A noteworthy feature is the absence of any continuous mountain range or chain of dominant peaks in this portion of the isthmus.

A shallow depression occupies the western portion of the region, its larger axis being nearly parallel with the Pacific coast. This contains the lakes Nicaragua and Managua. The former is 110 miles in length with an area of 3,000 square miles, and a mean altitude of 106 feet. Its greatest depth is 200 feet.

The climate of the region is tropical and insular, the annual range of temperature being small. The rainfall is greatest on the east coast, being nearly 300 inches at Greytown, and decreases somewhat uniformly westward, being less than 80 inches on the west coast. Connected with the decrease in rainfall there is a striking change in the character of the vegetation, the dense tropical jungle of the east coast giving place to open forests and savannahs in the west.

No rocks older than the Tertiary are found along the line of the canal. They consist of eruptive and sedimentary formations, the former including basalt, andesyte and dacyte and the latter calcareous sandstones and shales. In addition to these Tertiary rocks there are extensive recent alluvial deposits and the tuffs and lavas of the modern volcanoes.

The conditions throughout this region, but particularly in its eastern portion are favorable for rock decay and the regolith is unusually extensive. In the eastern section it consists of red clay at the surface with a depth of 10 to 30 feet, then blue clay with a somewhat greater depth passing downward into thoroughly weathered rock or saprolite in which the original structure is more or less perfectly preserved. The depth to hard rock varies from 50 to 150 feet. In the western section the regolith is much thinner and the red clay is almost entirely wanting the residual products being blue or gray.

The late geological history of the region so far as it can be made out, is briefly as follows: In early Tertiary time this portion of the isthmus may have been wholly submerged. At any rate marine sediments were deposited throughout a considerable part of its extent and this was accompanied by intense volcanic activity. In middle Tertiary time there was an uplift and long continued erosion, the constructional volcanic topography being obliterated and the region, at least toward the south, being reduced to one of low relief. The present basin of lake Nicaragua was then occupied in part by a gulf connected with the Pacific to the northwest, and in part by the valleys of tributary streams. The continental divide then occupied the hilly or mountainous region east of the lake, crossing the present

San Juan valley near Castillo. In late Tertiary or post-Tertiary time the isthmus was elevated at least 300 feet, and deeply dissected. Following the elevation was a renewal of volcanic activity. A series of vents on the Pacific side and their ejecta built a dam across the outlet of the gulf, thereby forming the lake basin. As this dam increased in hight the waters behind it were raised until they overtopped the contiental divide and escaped to the Atlantic, forming the present San Juan river. The region has suffered a recent depression by which the rivers were drowned and the estuaries thus formed have since been silted up.

"*The Faunas of the Upper Ordovician in the Lake Champlain Valleys,*" by THEODORE G. WHITE, of Columbia University. Results of a detailed study of the consecutive faunas contained in each stratum at numerous localities throughout the length of the valley. A complete section is afforded from the base of the Black River formation through the Trenton and terminating in the Utica. Species hitherto reported only from Canadian localities are found associated with those characteristic of the Trenton Falls type-province, showing the Champlain connection of Ordovician seas. Several zones characterized by restricted species are located, and also "conglomeratic zones." The fauna is very abundant and supplies a basis of comparison for similar detail study from other provinces. The occurrence of the Hudson River and Oneida groups in the region is questioned.

I. C. Russell, of Michigan University, gave a preliminary account of the general geology of the Cascade mountains in northern Washington, based on a reconnaissance made during the past season. The region treated of extends about sixty miles east and west along the Northern Pacific railroad and one hundred and twenty miles northward to the Canadian boundary. Carboniferous and Triassic rocks are exposed which the author divides into the Similkameen and the Ventura systems. The extensive Tertiary outcrops are divided into the Snoqualane slate, Winthrop sandstone, Camus sandstone, Swank sandstone, Roslyn sandstone, and the Ellensburg sandstone. There is an abundance of fossil leaves. Moraines and valley gravels constitute the Pleistocene beds. As to eruptive rocks, granite, andesyte and acid and basic dikes occur, but basalt is generally absent. The paper then discussed the laccolithic domes, the folds and faults, the Cascade peneplain and the Cascade plateau with its dissection. There are indications of several ancient glaciers on both sides of the Cascade range, but the northern drift is absent. Along the Columbia, Snake and Spokane rivers there are great terraces, due to climatic changes, but there is no evidence of recent submergence. Glaciers are now to be found in the Wenatchee mountains and the Cascades. Coal, gold, copper, iron, building stones, clays, etc., are found in the region.

"*The Geology and Archeology of California,*" by W J McGEE, of the Bereau of Ethnology, and W. H. HOLMES, of the National

Museum. Accepting the conclusions of Lindgren, Turner, and other geologists concerning the origin and age of the auriferous gravels, the authors described the deposits, the subsequent erosion by which they have been reduced to remnants, and the principal events in the geologic history of the region. Beginning with the base-leveled surface of a peneplain in early or middle Tertiary time, the region was apparently depressed and tilted westward in such manner that a number of parallel streams (prototypes of the present waterways) clogged their channels with beds of coarse gravel derived from the ancient Sierra rocks; later vulcanism supervened, and some of the waterways were further choked by the ejectamenta in such manner that tuff-beds, interspersed with gravel-deposits, were accumulated, while the accumulation ended, in some portions of the region, with outflows of andesitic and basaltic lavas. Afterward the region was lifted, and profound canyons were carved by the rivers draining the western slope of the Sierra; most of the preceding deposits were carried away, a few remnants only persisting in the form of table mountains, elevated tuff-beds, and gravel-streams, generally overlain by lavas and tuffs, while in the typical part of the region, the cutting extends from one thousand to three thousand feet below the Tertiary gravels, tuffs, and lavas, and into the obdurate rocks of the Calaveras and Mariposa formations. The fossils and relics recorded from the gravel-beds were described as (1), plant fossils; (2), animal remains; (3), mortars, pestles, and other stone artifacts, and (4), human bones. The plant remains have been found in limited quantity in a number of localities, usually in fine beds associated with the gravels and tuffs; they indicate ages ranging from about middle Miocene to late Miocene or early Pliocene. The animal remains are much fewer, but their testimony as to age coincides with that of the plants. The stone artifacts, all belong to a single cultural type—the type represented by the living Indians of the region (commonly known as Diggers), whose chief food-source is the acorn; their habits of life, including most of their industries, much of their language, the essential features of their social organization, and the distinctive features of their religion are adjusted to this food-source; they are as completely acorn Indians as the Dakotas were buffalo Indians. The implements used by them to-day, in making acorn-meal, are indistinguishable in material, form, and mode of preservation from those reported to have been found in the gravels associated with and commonly below the Tertiary lavas and tuffs. The only fully recorded occurrence of human remains in the gravels below the lava, is the case well known to geologists as the Calaveras skull. This fragmentary cranium has not been examined critically by the authors; but comparison of Whitney's reproductions of this specimen with related material in the National Museum indicates that it is to all appearances a normal Indian skull. The authors described their visit to the locality whence this specimen was reported, and their conferences with the dozen or more surviving miners and business men who were personally acquainted with the cir-

cumstances attending the discovery; of these survivors, two hold the skull to be a genuine fossil, while the others regard the affair as a joke, and several of them independently recount a history of the planting of an Indian skull, taken from the vicinity of a saline warm spring a few miles away, in the shaft to deceive a miner, and of later jocular conspiracies to deceive a local collector, and, in turn, the state geologist—indeed, one of the most substantial and highly-respected citizens of Angel's (a leading merchant and the present postmaster) declares that the skull lay in his store for six weeks before it was planted in the shaft, during a midday nooning, as a joke on the miner who innocently brought it to light on resuming work in the afternoon. Thus, so far as the contemporaneous human testimony goes, the record of the finding cannot be regarded as above question; and the authors pointed out the desirability of resting conclusion on the firm basis of observation and comparison, which any patient worker can verify. It was held to be inherently improbable—so improbable as not to be acceptable without abundant and unimpeachable testimony—that man, the most variable of all organisms, could have existed at a period so remote that no other animal species and few animal genera have survived, while even the more stable flora has been greatly modified; it was held even more firmly that, if Homo sapiens be admitted to have survived since the close of the Miocene, it is incredible that his skeletal characters should have remained so little modified as to permit identification of his cranium with that of the local modern tribe, and most firmly of all was it held to be incredible that the distinctive culture-stage represented by the mortars and pestles of the present California Indians could have survived throughout the vast period represented by the volcanic outflows and the subsequent erosion of the profound Sierra canyons, with the concurrent transformation of floras and extension of faunas, i. e., that an acorn culture could have begun at a time when the nascent Quercus flora was probably not yet fruit-bearing, and survived unchanged while the region was transformed from the Miocene peneplain to the present labyrinth of profound canyons.

In answer to an inquiry as to the supposed cumulative character of the evidence offered by relics from the gravels, it was pointed out that nearly all of the records were made by inexpert observers or second-hand collectors, not guided by scientific principles; and it was shown to be natural and even inevitable that untrained observers should fall into error as to the associations. The most common source of error was the misleading association produced in hydraulicking gravels buried beneath a heavy covering of tuff; in such cases, a great part of the material washed into the sluice-boxes really comes from far above the gravel horizon, some of it, indeed, from the surface. In one instance, the authors found more than a dozen mortars and a score of pestles within stone's throw of the cliff formed by hydraulicking the great Dardanelles mine near Dow's flat, where relics have been reported by the miners—indeed, in working down the

cliff, they found a mortar lodged forty feet below the surface, a pestle twenty feet lower still, and nearby another mortar on the bed-rock, all manifestly fallen from above. During their work, they had been compelled to recognize a considerable number of possible sources of error, with respect to association, against which early observers had not guarded. The communication concluded with the explanation that the investigation was not yet complete, but that it would be continued along each of several special lines, all tending to elucidate the archeology of California.

In the ensuing discussion, professor W. H. Brewer and professor S. F. Emmons raised questions concerning the alleged fossilization of the Calaveras skull, which the authors were not in position to answer, pending examination of the specimen; though they mentioned finding partially calcified Indian crania from caverns in the vicinity, where the Miwuhk Indians frequently dispose of their dead by casting them into the deepest caverns they are able to find. Major Powell noted the untrustworthy character of the testimony of unscientific men as to associations, instancing the Nampa figurine, alleged to have been found under the Tertiary lava sheet in Idaho, which a well-operator sought to palm off on him as a genuine discovery, and which was afterward actually foisted on a credulous collector, and published as evidence of high human antiquity. Professor J. A. Holmes described the discovery of an object, in Miocene deposits of the Coastal plain, which was attested to be in place in the undisturbed formation by affidavits of all finders, including the army officer in charge of the work; the object proving, on examination, to be a piece of a revolver of rather recent make.

One of the most interesting statements brought out by the discussion of this important paper was that of major Powell, that most, if not all, of the European claims to the great antiquity of man rest on evidence that is of a character analogous to that of the Calaveras skull, in the sense that it all has yet to be subjected to expert re-examination.

C. D. Walcott, director of the U. S. Geological Survey, made the important and rather startling announcement that during the past season he had discovered indisputable fossils in the Algonkian beds of Montana, about 4,000 feet below the base of the Cambrian. The remains consist of separated plates of crustaceans closely related to Eurypterus. Several specimens were exhibited by the speaker, and the fossiliferous horizon was stated to be about 80 feet in thickness.

"*An Unrecognized Process in Glacial Erosion,*" by WILLARD D. JOHNSON, U. S. geological survey. The glacial topography of mountains was analyzed, and the more distinctive

forms were discriminated from those of aqueous erosion. The recognized process has been that of scour, the action of which is downward and forward with the glacial advance. Glacial scour and aqueous erosion are alike incompetent and as a rule inimical to the production of many forms. An unrecognized process is that of sapping, its action horizontal and backward. The tendency with glacial scour is to produce sweeping curves and eventually a graded slope, while the tendency with the sapping process is to produce benches and cliffs. Sapping is altogether dominant over scour. Under varying conditions, however, its developing forms become obsolescent: their modification, then, by rounding off of angles, puts them seemingly into the category of scour-forms. The ultimate effect is truncation at the lower level of glacial generation.

"*The geology of the Yosemite National Park,*" by H. W. TURNER, of the U. S. Geological Survey. The Sierra Nevada was first formed as a great mountain range by folding about the end of the Jurassic, the slaty and schistose structures being referred to this time. At a later period, probably during the early Cretaceous, systems of joint planes were formed which intersected all of the older rocks of the range. When found in schistose rocks these joint planes cut the planes of schistosity at varying angles. During Cretaceous time the range was reduced in hight and the rocks which covered the granites were largely removed, especially in the southern portion of the range. When the drainage system of the Sierra began to be formed, the systems of joint planes exerted a strong influence on the courses of the streams. The much jointed zones disintegrated more readily, and because they were lines of least resistance, were more rapidly eroded and the tendency of the streams was thus to form canyons along the shattered zones. By the end of the Tertiary the range had been reduced to one of comparatively gentle slopes. In the northern Sierra Nevada enormous volcanic eruptions filled the river channels with lavas, so that the rivers were displaced and cut new channels; but this was apparently not the case with that portion of the range from Yosemite valley southward. Here the Pleistocene streams appear merely to have deepened the Tertiary channels. The region embraced in the Yosemite National park is exceptionally well exposed, hundreds of square miles being nearly devoid of soil or talus. The influence of the joint systems on the minor drainage can thus be seen to great advantage. With the larger canyons, however, this influence is less marked to the observer, but if the direction of the strongly developed joint planes be plotted on a map, the canyons will usually be found to have similar courses. The Merced river is thought to have already excavated a shallow valley over the site of the present Yosemite valley at the end of Tertiary time. After the late Tertiary or early Pleistocene elevation of the range, the rivers cut the present deep canyons. From the illustrations shown it was clear that the granite about Yosemite valley is intersected by a set of very marked vertical joint planes, the course of which is parallel to the general

trend of the valley. To the observer it is very apparent that these vertically jointed planes are the cause of the vertical cliffs. The entire canyon is believed to have been cut out by river erosion assisted by the jointing. Subsequently the valley, in common with the other canyons of the high Sierra, was filled with glacial ice and a large amount of talus may in this way have been removed. This glacier left a number of moraines at the west end of the valley which have served as barriers to the drainage and caused the formation of the valley floor.

"*The Origin of the Grahamite in Ritchie Co., W. Va.;* by I. C. WHITE, state geologist of West Virginia. Grahamite is a black, coaly mineral, looking like anthracite which is very closely allied to the albertite of Nova Scotia. It consists essentially of 79 per cent. carbon, 6½ per cent. hydrogen and 14 per cent. oxygen. In Ritchie county, it occurs in a vertical fissure nearly five feet wide, seven miles from the ridge known as the "oil-break," which is the top of an anticlinal fold. Years ago it was mined as a fuel, but never at a profit. Within about a year well-paying oil wells have been put down within a few hundred feet of the fissure. The theory of origin is that the fissure, which was caused by the forces producing the anticline, tapped the Pottsville conglomerate oil-sand, and that the oil flowed until nature plugged up the orifice with the oxidized oil, paraffine, tarry products, etc., form the consolidation of which the grahamite has resulted.

"*Structure of the Iola Gas Field, Allen County, Kansas,*" by EDWARD ORTON, Columbus, O., read in the absence of the author by I. C. White. Natural gas is more widely distributed, geologically and geographically, and exists in larger quantity than any one would have claimed 20 or even 10 years ago. Its productive horizons cover the entire Paleozoic column of the country. Cities supplied, at least partially, with natural gas for fuel and light are no longer uncommon. Two distinct divisions can be made of its accumulations, viz.: That which is stored in impervious rocks as shales, most limestones, etc., and that which is found in porous rocks. These divisions may be provisionally styled Shale gas and Reservoir gas; each having characteristics of its own. Shale gas occurs in comparatively small wells. Its wells lack uniformity of rock pressure. It does not occupy definite horizons; it exists independently of petroleum in many cases, has staying properties—does not depend on the structural arrangement of the strata that contain it. Reservoir gas is found in great wells; approaches uniformity of rock pressure in each subdivision of territory, occupies definite horizons, is accompanied by oil, its wells generally come to a sudden end—is entirely controlled by the structure of the rocks in which it is accumulated. Two structural phases of rocks are specially important in this connection, the anticline and the terrace. The time has come for the acknowledgement of structure in reservoir gas fields even in advance of measurements. The Iola gas field is one of great promise. Its

source is in a sandstone of the Cherokee shales, or near the bottom of the coal measures. It proves to be a terrace of well marked character. For seven miles the top of the gas rock has an elevation of 131 feet above tide, rising at no point more than 45 feet above this. At this summit, the largest well of the field is located, yielding 10,000,000 cubic feet per day. The gas is being largely used by the lead and zinc smelters of the Joplin district.

"*The Conshohocken Plastic Clays*," by T. C. HOPKINS, State College, Pa. The plastic clays near Conshohocken, Pa., form an isolated deposit. The resemblances to the New Jersey and Gay Head clays in colors, texture and structural features suggest clays of the same age. The location and character of the deposits were briefly described.

Gold Mining in the Klondike District; by J. B. TYRRELL. Canadian geological survey. The geology of the Klondike region was described and illustrated with lantern views made from photographs taken by the author last summer. He stated that the stream gravels were of the usual type of gravels, but that the bench gravels were lateral moraines left by glaciers and that the gold content had not been transported from a distance.

Ripple-Marks and cross bedding; by G. K. GILBERT, U. S. geological survey. The general theory of ripple-marks as developed by Darwin and others was stated and illustrated by means of diagrams. The relation of the dimensions of ripple marks to the waves causing them was stated to be, in general, that the distance from crest to crest of the ripple marks is one-half the hight of the waves making them. The author referred certain large undulations in the Medina sandstones near Lockport, N. Y., to ripple marks. A lantern slide of one of these giant ripple marks 23 feet across and 29 inches deep was shown. Others must have been 30 feet across, indicating waves 60 feet high in the Medina seas. When the waves are interfered with by currents confused ripple marks result.

"*The Glacial Lake of the Nashua Valley*," by W. O. CROSBY, Massachusetts Institute of Technology. The Nashua is the largest stream east of the Hudson-Champlain valley, flowing throughout the main part of its course in a northerly direction, and the upper part, especially, of its valley is deep and well defined, presenting, thus, ideal conditions for the development of the phenomena of glacial lakes. The pent-up waters were effluent first southward at elevations successively of 760 and 440 feet, being then tributary to the Blackstone river and Narragansett bay; and later southeastward at an elevation of 370 feet through the pass now occupied by the Central Massachusetts railroad. This was the principal and most persistent stage of the lake; and the effluent waters were probably, through the similar blocking of the Assabet and Sudbury valleys by the ice-sheet, forced across the country into the valley of the Charles river and Massachusetts bay. During this stage of the lake extensive delta plains

were formed, especially in the district south and west of Clinton, where the State is building an immense reservoir as an addition to the water supply of Boston and the Metropolitan district. The deforesting of this area gives great topographic distinctness to the deltas and other features of the lake, and the numerous deep borings and extensive excavations have very fully developed the structure of the deposits.

"*A Remarkable Landslip on the Rivière Blanche, Portneuf County, Quebec*," by GEORGE M. DAWSON, director of the Canadian geological survey. In this paper a brief account is given of the landslip that occurred on May 7th, last. It affected the thick deposit of Leda clay that floors this part of the St. Lawrence plain and serves to indicate that a clay of this character may, under certain circumstances for a short time, behave almost as a liquid. An area of about 86 acres flowed out, leaving banks 15 to 30 feet high and filled the river valley, which is 1,000 feet wide, for a distance of two miles below the narrow outlet through which it escaped, though the slope of the valley is only fifteen feet per mile.

"*The Volcanoes of Southeastern Russia*," by H. FIELDING REID, of Johns Hopkins University. After the meeting of the international geological congress at St. Petersburg in 1897, the author visited the high volcanoes of Elbruz, Kazbec and Ararat. The paper gave a brief description of these famous mountains, with the help of lantern illustrations from photographs by the author. Each of the two summits of Mt. Elbruz shows a crater and Mt. Kazbec shows a summit crater. The top of Great Ararat consists of two domes, but there seems to be no present indication of a summit crater. Deep snow covers the summit. Little Ararat shows indistinct evidence of a summit crater.

"*Ice Sculpture in Western New York*," by G. K. GILBERT, U. S. geological survey. Careful study of the Niagara escarpment in Niagara county shows that its greater features are preglacial, but glacial erosion wrought important modification. The Medina shale was so deeply sculptured as to obliterate its preglacial relief and substitute a broad fluting in the direction of ice movement. At Thirty Mile point a mass of strata several hundred feet broad was moved by the ice.

"*The Wind Deposits of Eastern Minnesota*," by C. W. HALL and F. W. SARDESON, University of Minnesota. The paper treated of the character, origin and age of the lag gravels and dune sands so frequently seen in eastern Minnesota—more particularly in the district between the Mississippi and Saint Croix rivers. These deposits in the vicinity of Minneapolis were more particularly studied and their relations to some fossiliferous post-glacial water deposits were considered.

"*The Iroquois Beach at Toronto and its Fossils*," by A. P. COLEMAN, Toronto, Canada. The Iroquois beach north of lake

Ontario, was long ago mapped in outline by Spencer, but many details in this shoreline remained to be filled in. Near Toronto two bays are found, one near Carlton on the west, the other near York on the east. Each had an area of several square miles and was cut off from the main lake by a gravel bar like the present Toronto island. Horns of caribou are common in the Carlton bar and teeth of the mammoth have been found in the bar near York. Fresh water shells of four species, Campeloma decisa the most common, are found in beach gravels of Iroquois age near Reservoir park, Toronto. These are the first fresh water fossils found without doubt in the Iroquois beach deposits. As the main Pleistocene beaches from Agassiz to Iroquois contain fresh water shells, they must have been formed in lakes and not arms of the sea. The numerous marine shell-bearing deposits of the east of Canada cease before lake Ontario is reached.

"*Thames River in Connecticut*," by F. P. GULLIVER, Southboro, Mass. The cuts made for the new line of the New York, New Haven & Hartford railroad in eastern Connecticut along the east side of the Thames river between Norwich and New London have revealed the structure of the terraces which were called Champlain deposits by J. D. Dana. Upon the theory that these were formed by flooded rivers, it was difficult to account for the forms below the general level, such as eskers, which are found in certain places.

These sections show many delta lobes of fine sand pointing down stream and toward the sides of the old valley. These are overlain by the coarse deposits of gravel and bowlders up to one foot in diameter, such as are found in Alaska on the delta in front of the ice. In places these deposits fill in completely the space between the river and the till-covered rock slopes of the drowned valley; but in some of the bays of the side streams there are lobate fronts, the axis of each lobe pointing from the center of the main valley into the valley of the tributary. This suggests that these deposits were formed when an ice-tongue filled the center of the valley and the rock waste was washed out in all directions from it; so that the terraces and the eskers were formed at the same time, viz: when the ice margin was retreating.

"*The Gold-Bearing Veins of Bag Bay, Western Ontario.*" PETER MCKELLAR, Fort William, Ont. Read by Robert Bell, in the absence of the author. The object of this paper is to show the peculiarities of the gold-bearing veins in the granite area at Bag bay, Shoal lake, west of Lake of the Woods, Ontario. These veins are characterized by the smallness of the quartz fissures compared with the quantity of valuable ore they yield under development.

In order to get through the long programme in three days it was necessary to form a temporary petrographic section on the last afternoon, and the following papers were read then:

"*Differences in Batholitic Granites according to Depth of*

\mherst College. The paper first
sic eruptives at Kirtland, N. Y., and
. then stated that in the intervening
: wanting. Between the Hudson and
re rare until the region of the Con-
ites of Massachusetts may be divided
utcrops extending from south of Provi-
. often hornblendic and of very uniform
iartz porphyries, rhyolytes, granophyres,
s near the Connecticut which range from
. and containing great blocks surrounded
g rare earths; a third, intervening series
ross the state from north to south. These
t at varying depths below the old cover
series like the zonal sections of the anato-
w that the granites, unlike the coastwise
eat quantities of the superincumbent schists,
their mass. In favorable sections cut near
1 of the two kinds of rock it is possible to
e, and at the same time to carry over its sur-
of the different schists which formerly mant-
en melted into it. Where a rusty, graphitic,
. the granite, the latter is garnetiferous, full of
rolite, and contains even in the centers of the
pars scales of graphite derived from the schist.
osses, the granite becomes hornblendic. Where
, the granite is free from the above peculiarities
m mica, with here and there a thin band of the
ng at its ends into disconnected quartz grains.
ithout porphyries or basic associates, or veins
are of very angular texture and often coarsely
generally of coarse, pegmatitic character, as if
inclosed schist had influenced their crystalliza-

asic Dikes in the Manhattan Schists, New
J. F. KEMP, Columbia University. Horn-
ow belts have long been known in the prevailing
ttan island. The paper described with a detailed
urrence near the Columbia University campus.
aphic details of dike and walls were given.

the North Shore of Long Island Sound
tions on the Granites of the Atlantic
By J. F. KEMP, Columbia University
r of the crystalline rocks along the sound from
gansett bay was outlined, and it was shown that
e gneisses, with profound foliation, but with some
nsiderable basic hornblendic and biotitic schist.
tic and Westerly, R. I., and at New London,

Millstone Point, Stoney Creek and some minor localities, were discussed. They were shown to be biotite-granites or biotite-muscovite granites of several varieties. Although they have nearly or quite the same mineralogy as the prevailing gneiss of the region, the attempt was made to establish their intrusive character, by their relations to the wall-rocks and by their peculiar inclusions of the basic hornblendic and biotitic schists. The remarkable development of pegmatytes that everywhere characterize the region was also discussed both as regards mineralogy and geological relations. The paper concluded with a general review of the granites of the Atlantic sea-board and showed that they were with few exceptions biotite granites. Such analyses as are available were used in illustration.

Augite-syenite near Loon Lake, New York. By H. P. Cushing, Adelbert College. An interesting section exposed in a railroad cut near Loon Lake, shows an intrusive rock which has caught up fragments of the Grenville series. The rock is related to the augite-syenites but the chemical analysis shows some unusual features. A large area of anorthosite mapped in Franklin county, N. Y., the past summer, was found to grade into similar rocks on all sides, which are regarded as varients of the gabbro magma. They present a range from rocks of the acidity of granite to basic gabbros.

On the Phenocrysts of Intrusive Igneous Rocks; by L. V. Pirsson, Yale University. The term phenocryst is a convenient substitute for "porphyritic crystals." There are two kinds, the "single" and the "recurrent," the former of which is a mineral which does not occur in the ground mass also, while the latter does. The phenocrysts of extrusive rocks were not considered in this discussion. The author argues for but one period of crystallization, though its conditions are very complex. Of these conditions the chemical are fully as important as the physical, of the latter the viscosity of the magma and the rate of cooling have great influence on the result. Strong arguments were adduced to show that the phenocrysts are not "intratelluric," but that they were formed in place after the intrusion of the rock. The following familiar facts constitute some of the arguments against intratelluric origin: (1), Absence of phenocrysts from contact zones; (2), they are sometimes lacking in dikes and sheets when the parent laccolith abounds in them; (3), the microlites surrounding the phenocrysts have been pushed into their present position by the growing crystal and are not indications of flowage. The most abundant minerals have a tendency to develop at the expense of the others, but too great uniformity is not to be expected of nature.

Geology of the Mica Deposits in the United States; by Joseph A. Holmes, state geologist of North Carolina. The deposits of commercial mica in the United States, though widely separated, are limited to a few districts. They have been worked to some extent along the Appalachian system of mountains in New

Hampshire, Virginia, North Carolina, the Black Hills region of South Dakota, the Cribbensville district in northern New Mexico, western Idaho, and additional deposits of promise have been found and developed on a small scale in the Appalachian region in Maine, South Carolina, Georgia and Alabama; and in California, Wyoming and Nevada.

These deposits of commercial mica are all found in pegmatyte "veins" or dikes; and these pegmatyte dikes occur in gneissic and granitic rocks which are usually classed as Archæan. The dikes yielding the best and largest quantities of mica are found in the hornblendic and micaceous gneisses and schists in places parallel to, but generally breaking across the schistosity of these rocks at varying angles. The dikes vary in thickness from a few inches to more than 250 feet, and can be traced for a distance varying from a few feet in the smaller ones to sometimes several miles in the larger ones. In some cases they are quite irregular and have arms branching out in almost every direction. Many of them are vertical, while others are nearly horizontal, and still others vary very greatly.

The pegmatyte consists mainly of quartz and feldspar in equal or variable proportions and muscovite mica; in some places the quartz and feldspar are somewhat uniformly distributed throughout the pegmatyte mass, while in other cases the two are fairly well separated, the feldspar sometimes crystallizing out into masses more than a ton in weight. In addition to these three common minerals there occur in these dikes a large number of minerals with varying degrees of rarity. The dikes in certain localities sometimes contain a considerable number of these accessory minerals—20 or more being occasionally observed in a single dike—and in other regions few or none of them are to be found. As a rule crystals or "books" of commercial mica need not be looked for in dikes or veins under two feet in diameter, but there are cases in which these "books," 2x2½ feet in diameter, have been found in dikes, the width of which was scarcely greater than these figures. On the other hand in case of some of the largest dikes no mica whatever of commercial value is to be found.

Generally the "books" or crystals of mica are scattered promiscuously through the matrix of quartz and feldspar and in mining operations a large amount of useless material has to be blasted down and removed from the mine in order to secure the commercial product: in other cases, however, the "books" or crystals of mica occur in the outer part of the dike near the wall rock and in these cases the mica "lead" can be more easily followed. In some cases the mica constitutes as much as 10 per cent. of the total mass of the dike, but in the majority of cases it will prove to be less than one per cent. of the total. Of the mica taken from the dike in ordinary mining operations, usually less than 10 per cent. and sometimes less than 2 per cent. has a commercial value as sheet mica; the remainder being either thrown away as waste material or pulverized for commercial uses.

The age of these pegmatyte dikes in different parts of the country varies considerably. In crystalline rocks exposed in the lower part of the grand canyon of the Colorado in northern New Mexico, the dikes break through the granitic rocks, but come unconformably against the base of the Algonkian series there, and are consequently pre-Algonkian in age. All of the larger dikes observed in the Rocky Mountain region have been to a greater or less degree involved in the schistosity and other structural modifications of the crystalline rocks, and consequently must have been formed either prior to or during the earlier stages of the uplift of these mountains. In the Appalachian region these dikes are not in most cases extensively involved in the schistose structures of the rocks, but in some instances they have undergone considerable changes in connection with the production of these structures. The condition of the material in the dikes seems to indicate that they were formed either prior to, or during, the early stages of the uplift of these mountain regions as in some cases they are involved in folds quite similar in general character to those typical of the Appalachian structure.

Occasionally the sheets of mica have themselves been folded under pressure, but as a rule they show no such disturbance, having been, like the coarse feldspar and quartz of the dike, but little modified in connection with the mountain uplifting. These blocks of mica, however, frequently have their commercial value in large measure destroyed by the reproduction of what is called "rolled" or "ribbon" mica, the sheets of mica being cut into narrow strips with parallel edges. These edges of the rolled mica appear in all cases to be parallel to certain axes of crystallization and the cause of this "ruling" and the conditions under which it has been produced are not well understood.

The following papers were read by title:

Stratigraphy of the Pottsville Series in Kentucky; by Marius R. Campbell, Washington, D. C.

American Homotaxial Equivalents of the Original Permian; by C. R. Keyes, Des Moines, Iowa.

Geology and Physiography of the West Indies; by Robert T. Hill, Washington, D. C.

Surface Features of Northern Kentucky; by Marius R. Campbell, Washington, D. C.

Geology of the crystalline rocks of Manhattan Island and Vicinity; by F. J. H. Merrill, Albany, N. Y.

Conditions of Formation of Dykes and Vein Fissures; by N. S. Shaler, Cambridge, Mass.

Origin of the Highland Gorge of the Hudson River; by F. J. H. Merrill, Albany, N. Y.

The Iowan Drift; by Samuel Calvin, Iowa City, Ia.

Loess Deposits of Montana; by N. S. Shaler, Cambridge, Mass.

Spacing of Rivers with Reference to the Hypothesis of Base-leveling; by N. S. Shaler, Cambridge, Mass.

Glacial Phenomena in the Yukon Valley; by J. B. Tyrrell, Ottawa, Can.

The officers elected for the current year are: President, B. K. Emerson, of Amherst College; First First Vice-President, George M. Dawson, of the Canadian Geological Survey; Second Vice-President, C. D. Walcott, of the U. S. Geological Survey; Secretary, H. L. Fairchild, of Rochester University; Treasurer, I. C. White, of the West Virginia Geological Survey; Editor, J. Stanley-Brown, of Washington, D. C.; Librarian, H. P. Cushing, of Western Reserve University; Councillors, J. S. Diller, J. M. Safford, W. B. Scott, M. E. Wadsworth, W. M. Davis, J. A. Holmes.

The following men were elected Fellows of the society: A. R. Crook, Evanston, Ill.; N. F. Drake, Tientsin, China; A. H. Elftman, Grand Marais, Minn.; M. L. Fuller, Boston, Mass.; A. W. Grabau, Cambridge, Mass.; J. H. Pratt, Chapel Hill, N. C.; F. C. Smith, Deadwood, S. D.; F. B. Van Horn, Cleveland, Ohio; T. G. White, New York City; S. W. Williston, Lawrence, Kansas.

SOME NEW FOSSILS FROM EASTERN MASSACHUSETTS.

By Dr. Walter E. Hobbs, Stonybrook, Mass.

Algonkian. The existence of a metamorphic sedimentary terrane, intermediate between the Cambrian and Archæan, according to the generally understood delimitations of those formations, in eastern Massachusetts, has been touched upon before in the few papers that deal with the geology of this district; but a systematic treatment has not been published in which enough detail has been given to make the relations of the formations clear. I now propose to give a preliminary paper on a region of about sixty square miles, situated on the western rim of the Boston basin and extending west and northwest from the city of Waltham for ten miles across a region usually left uncolored on geological maps. To the east, we have the well known Boston Basin series, consisting of the Roxbury conglomerate and the Cambridge slate, with various intrusives, and flanked to the eastward by the three

Cambrian localities of Nahant, Weymouth, and Braintree, the first two Lower Cambrian and the last Middle Cambrian. These are probably all of Cambrian age. The Basin series is terminated abruptly on the west by a fault.

In the small area west of Waltham, we have a definite stratigraphical series beginning at the bottom with a quartzyte member which for convenience I have called the Stonybrook quartzyte from the locality where it is best exposed, a method of naming generally followed. This member has a dip of about 60-70 degrees N. W. and a strike about N. 40-50 E., with thickness of at least 500 feet. The base rests on a red porphyritic granite; a red feldspathic element in the quartzyte indicating an arkose. The granite which contains large phenocrysts of orthoclase, includes masses of diorite and upon closer study will undoubtedly be found to consist of separable members here considered as a unit and placed provisionally with the Archæan. The quartzyte becomes exceedingly fine grained in the upper portion and it may yet be found necessary to separate this portion as a silicious or magnesian slate. Numerous small faults make the stratigraphical relations exceedingly complex. The upper portion of the quartzyte shows an excellent alternating passage into the next member, the Kendal Green slate. This agrees in dip and strike with the first, but attains a much greater thickness, estimated at probably over 5,000 feet. It is in the main a schistose slate, using the term slate in its widest sense, consisting of hornblende, quartz and many other constituents, the entire description of which would be too great a task for the scope of this paper.* The primary constituents vary in the direction of dip, owing to variations in the conditions of sedimentation. The original deposit must have been thickly bedded since the stratification is easily lost in process of metamorphism. The upper portion marks a return of the conditions of the coarser materials of the underlying formation.

The third member of the series is the Lincoln slate. This has the usual dip and strike, one of the marked feature of the

*The reader is referred with pleasure to the papers published by Mr. John Sears in the Bulletins of the Essex Institute of Salem, Mass., for petrographical descriptions of similar rocks from an area to the northeast of that of the writer which is on the line of strike of the formations described here.

region being the uniformity of these directions, and consists of a micaceous slate, or schist, containing lenticular masses of an impure cherty limestone. The thickness of this member is also probably over 5,000 feet. The schistosity is parallel to the plane of dip so far as observed, and is well developed and generally uniform in amount.

It is with the Lincoln slate that we are chiefly concerned in this paper, owing to the discovery of organic remains by the writer. These remains consist of the borings of Annelida, together with the surface material cast out of the borings and what appear to be integumentary plates mingled with a few scattered worm teeth. These occur in a silicious, or cherty, limestone bed of lenticular shape and of limited extent, situated about one mile northwest of the R. R. station of South Lincoln. The integumentary plates do not suggest the Hyolites shells, usually so common in Cambrian rocks, being more suggestive of the carapaces of some Annelid; yet it would be rash to conclude that there are no Hyolites present; what we seem to have is a decomposed mass of organic matter composed very probably of fragments of all the inhabitants of the sea of that time. In places, the limestone becomes black with carbonaceous material, but it is usually of white to grey highly crystalline texture, containing both primary and secondary quartz. The mechanical movements of the region have produced, as a rule, more flowage than shearing or faulting in the limestone, whereas, in the adjoining slate, which is more brittle, the reverse has occurred.

A hypothesis is plausible that the cherty matter, in part at least, came to its position in the limestone through the mixing habit of Annelida, being transported while in process of digestion from the silicious layers to the calcareous ones. The weathered surface is very suggestive of this, the loose aggregations of chert appear to have originated thus and to have been left in the little heaps so characteristic of worm action at the present time; these heaps remain or are scattered as chance determines.

One interesting feature was observed with the microscope where a burrow passed vertically upward through an integumentary plate, leaving a circular hole with the edges bent upward and outward. It is unlikely that the locality will ever

have many examples of these remains as metamorphism has been sufficiently severe as a rule to destroy almost every trace of a former life, excepting the semi-stratified arrangement of the silica presumably due to worm action.

These are the oldest remains yet described from Massachusetts. The stratigraphical determinations upon which the age of these remains is based are as follows: a greater degree of metamorphism, of the regional kind (a criterion of proved value), compared with the Cambrian to the east, the region chosen for special study being clearly older than the sediments of the Boston Basin series, the two being found in close proximity yet showing divergence in dip and strike. Secondly, there are at least three systems of dikes found in the older Algonkian series not found in the Boston Basin series. A fourth system of dikes although relatively scarce is found to an equal evtent in both areas. The evidense in this case is, I think, small but reliable. The difficulty has been that the dike materials are so nearly alike in the different systems that it is difficult to separate them lithologically to advantage, but by supplementing this evidence with the habit of occurrence, a sequence is obtainable. The three older systems have different directions from the fourth, showing a possible change in the stress, the diking being dependent upon faulting; this would require a lapse of time. The presence of newer systems of dikes in the Basin series, probably derived from a center of disturbance to the east of the present coast line, makes the dike evidence exceedingly complex. The results of the writer's studies are that every system of dikes in the basin has, or would have, if the disturbance had penetrated far enough, its counterpart in the area here described while the reverse is not true. The number of dikes, excluding local multiplications, may also be considered. The great number in the older group has given rise to the mistaken idea that the whole of a belt which would include the Stonybrook and Kendal Green members was diorite. It is needless to say that such a mistake would never be made in the basin: that series is comparatively unaltered. The transition is accomplished to the observer by stepping across a fault line. It is evident to the experienced eye that the Basin series has been deposited on the eroded surface of the older series. A third ground for

separation is this unconformity. The Stonybrook quartzyte has been found to underlie the Basin series, but the Kendal Green slate is not found, having been eroded.

Let us turn now to the history of the region as it may be read from the sequence of the strata. Upon an ancient Archæan continent situated probably to the east of the region studied, the Algonkian sea transgressed, gradually deepening, until the slate stage of deposition was reached. This condition seems to have prevailed for a long time, probably, if the time of erosion succeeding it be added to it, a time at least one-half as long as that from the Cambrian to the Pleistocene. It will probably be long a matter of uncertainty, but, comparing this series with the tolerably complete and legible succession of the Appalachian region, it is possible to see that the time element is great. There seems to be wanting a name for this older series and, if it be found to be extensive enough to warrant so broad a term, the name Appalachian would be the nearest name of general application. There are fundamental formations throughout the extent of the Appalachian range where erosion has been sereve enough to expose them and it was doubtless folding along the same general line that tilted the rocks of the region here described.

To continue with our history, having already implied a time of deposition succeeded by a time of erosion and elevation, this elevation being accompanied by volcanic phenomena, we next come to a second submergence beneath a Cambrian sea, probably with the main continental mass northwest. This was followed by a second upheaval, also a time of volcanic action. Then came a depression beneath a Carboniferous sea. It is one of the interesting problems of this region whether this period of sedimentation included Triassic time. Possibly some of our newer diabase is an attendant upon conditions like those of the Connecticut Valley Triassic. This was the last submergence, so far as known, the Tertiary formations which play so important a part on the south Atlantic seaboard becoming reduced to a few island patches off our coast before finally passing from sight altogether beneath the sea.

Summary. The principal points touched upon in this paper are of course the discovery of fossil Annelida in a Pre-

Cambrian series with the determination that the series is Pre-Cambrian.*

Middle Cambrian. The Cambrian of America has been least studied in the Middle or Paradoxides zone, mainly owing to the relative paucity of the strata of that age, but, nevertheless, much has been done in places; for example, the St. John's group has been carefully studied by Matthew in New Brunswick. It is, then, important that each new bit of evidence be carefully garnered and studied. In accordance with this plan I began the study of the locality of Braintree a few years ago, carrying on the work as opportunity served. It is a promising locality for extensive and systematic work and it will doubtless yet give us a large fauna. The fauna, as is known at present, is as follows: Trilobita,—*Paradoxides harlani* Green; *Agraulos quadrangularis* Whitfield; *Ptychoparia rogersi* Walcott; Pteropoda,—*Hyolites shaleri* Walcott, and *H. haywardiensis* Grabau. To these I have to add a brachiopod, *Obolella gamagei*, n. sp.

OBOLELLA GAMAGEI, n. sp.

Description. Dorsal valve (?). General shape, elliptical or subcircular, appearing slightly wider on the left side of the longitudinal axis, owing to distortion. Surface relatively smooth, two well marked concentric lines of growth being present, also some obscure radial plications, best shown on the left side of the longitudinal axis; the position and obscurity of these striæ mark the species as being a relatively smooth shell type. The beak is less prominent on the whole than in the nearest related types, Obolella crassa Hall and O. atlantica Walcott, being very similar. Probably the internal shape was not materially different. The beak of the specimen was detached when the slab was split apart, adhering to the opposite side, when this was cleaned away, the form was found to be as indicated by the dotted

*The writer wishes to direct attention to the work of Mr. John Sears, of Salem, Mass., as being in a region (Essex county) on the line of strike of the formations found in this area, Middlesex county. Mr. Sears has made discoveries of fossils in limestone similar to that described by the writer, but the limestone of Essex county is described as the remnants of a superficial sheet belonging to the Cambrian off the coast. The researches of the writer result in the conclusion that the limestone of Lincoln can only be older than the Cambrian, being interbedded in the Lincoln slate. The existence of worms or even of Hyolites does not prove a Cambrian age. We have a vast time before the Cambrian out of which the highly differentiated Cambrian faunas came. The persistence of the type Lingula is a warning against the localization of genera in time and space. There is nothing to show that Hyolites had not a hoary past at the beginning of the Cambrian.

OBOLELLA GAMAGEI.

line in the illustration, hence the dotting in this case does not indicate conjecture.

Ventral valve (?). Probably represented by detached and much distorted specimens on the same slabs, there being the four impressions of the single shell, two containing original organic shell-substance. This valve scarcely affords any additional facts, except, perhaps, that it was the larger of the two valves.

Dimensions. Dorsal, 6.4 mm. on the longitudinal axis by 7.4 mm. on the transverse axis. Ventral not accurately measurable.

Formation and Locality. Paradoxides zone, Middle Cambrian, East Braintree, Mass. The specimen was obtained from a ledge below high tide level, 75 or 100 feet east of the well known quarry at this locality, in a compact greenish grey, silicious, slate or argillyte, more thinly parting than the quarry rock and unusually full of trilobites.

So far as I have been able to find, this is the third species of Obolella described from the American Middle Cambrian; the others being *O. nana* Meek & Hayden, and *O. polita* Hall. The specimen is pitted on the surface as if from the depredations of some Cliona-like animal.

The specific name is given in honor of a friend, Miss A. O. Gamage, South Bristol, Maine, in recognition of her services to the writer. Type specimen is to be presented to the Boston Society of Natural History for exhibition.

[Contributions to the Mineralogy of Minnesota. IV.]

CHLORASTROLITE AND ZONOCHLORITE FROM ISLE ROYALE.

By N. H. WINCHELL, Minneapolis, Minn.

Chlorastrolite. Although not known on the Minnesota coast is in the same rocks on Isle Royale. The literature of this American mineral shows an interesting history. Discovered by Dr. C. T. Jackson when he had charge of the survey of the United States mineral lands of the lake Superior land district, it was analyzed by J. D. Whitney in 1847,* after the charge of that survey passed to Foster and Whitney. It was analyzed by Hawes in 1875† who came to the conclusion from the chemical composition and its variation, that it is not a homogeneous mineral, and was believed by him to be an impure condition of prehnite. In 1888 Lacroix showed that its optical characters ally it with thomsonite, the optic plane being transverse to the fibration. Dana, in the last edition of his mineralogy (1892), considers it of doubtful authenticity, placing it in an "appendix to zeolites," among synonyms and questionable species.

It occurs as small pebbles on the beach, but is also in the trap rock. It has a finely radiated structure, and stellate markings of light and dark green on the smoothed surface. Its hardness and beauty have given it considerable value in the market as a gem. The individual specimens are rarely larger than a pea, but sometimes reach the size of half an inch in diameter. The fibres are fine, rigid and uniform, and are elongated with n_m. They vary in brightness in convergent light in proportion as they expose to observation the obtuse or the acute optic angle. Specific gravity is 3.155. Hardness, 5.5. Chlorastrolite has a higher index of refraction than thomsonite, and its extinction varies to a maximum of about 20° from the fibration. It has a distinct pleochroism, being colorless and light-green.

Hawes and Lecroix both mention impuraties in the specimens examined by them; in the specimens belonging to the collection of the Minnesota survey, from which thin sections have been made, the mineral is quite pure, showing only a

*J. Nat. Hist., Boston, V. 488, 1847.

†Am. Jour. Sci., X. 25, 1875.

few scattered spherulites of delessite. Whatever the impurities, whether of quartz, delessite, oxide of iron or prehnite, it is apparent that they have no part in the true nature of the mineral itself. It is quite likely, however, that, in making a chemical analysis, these would be included, and they probably explain the lack of homogeneity which such analyses reveal. These impurities do not affect the purity of the surrounding fibres.

The mineral has a strong individuality, as to fibrous, stellate structure, and constancy of optical orientation, as well as to color. It is quite likely therefore that if an analysis be made so as to exclude the inclusions which are foreign to the mineral proper, its chemical characteristics will be found as distinct as its physical. Following is the analysis given by Whitney:*

SiO_2	36.99
Al_2O_3	25.49
Fe_2O_3	6.48
CaO	19.90
Na_2O	3.70
K_2O	.40
H_2O	7.22
	100.18

Localities. On Isle Royale this mineral is found at Chippewa Harbor, Lucky bay, and Rock Harbor, all on the south shore and in the same stratigraphic horizon.

Zonochlorite. Many of the pebbles of chlorastrolite have not the characteristic structure and beauty which have made them celebrated amongst lake Superior minerals, but present in general a dull green color and probably should not be allowed the name of chlorastrolite. This general greenness is sometimes quite dark, and in other cases it seems to fade into a very light green resembling that of lintonite, in the same way that mesolite fades in color into lintonite. In a similar manner it fades out into a white structureless substance whose hardness is less, but also sometimes into a pinkish zeolitic

*Geology of the Lake Superior Land District. Part II., p. 97, 1851; Jour. Bos. Soc. Nat. Hist., V. 488, 1847.

substance which resembles mesolite. The idea is suggested by an examination of a large number of such transitions that the green structureless substance is a transition stage between chlorastrolite and mesolite, the iron element prevailing on one side and not on the other. It seems likely that this green structureless mineral may be that which has been analyzed and named zonochlorite by A. E. Foote (Am. Assc. Adv. Sci., 65, 1873; Am. Jour. Sci. 1873). Probably no definite mineral composition or structure can be detected in this green substance, the extremes only being identifiable, viz., mesolite on one side and chlorastrolite on the other. That these two minerals are closely allied in origin, structure and composition, differing principally in the content of iron, is evident not only from the chemical composition and optic character but also from their association often in the same amygdule. Such association sometimes illustrates a sudden transition from one to the other and sometimes a gradual one, with a considerable amount of the amorphous green mineral. The re-examination of zonochlorite by Hawes (Am. Jour. Sci. x. 24, 1875) shows that it is not a homogeneous mineral. He describes it as having earthy green particles as impurities disseminated in a white mineral. Not having any opportunity of examining the original zonochlorite, it is only intended as a reasonable suggestion that it may be the same as the amorphous green substance associated with the chlorastrolites of Isle Royale.

Locality. The original zonochlorite was found by Foote in the amygdaloid of Nipigon bay, north shore of lake Superior.

ON THE OCCURRENCE OF QUENSTEDTITE NEAR MONTPELIER, IOWA.

By Dr. Otto Kuntze, Iowa City.

Iron sulphates in their various composition as neutral or more or less basic salts or with a various amount of water occur very sparingly in nature as minerals and are only met with under certain favorable conditions. Without exception they are always secondary minerals, i. e., resulting from the decomposition (oxidation) of other primary minerals as pyrite, marcasite or chalcopyrite. As the oxidation of these minerals is a very slow process and the solubility of the resulting sulphates is relatively large, the oxidized portion will be washed off by the excess of the percolating water and may be deposited after a more or less long way through the strata at any favorable locality in a fissure, mostly in the form of limanite or other insoluable iron salts, as the often not inconsiderable amount of organic matter, contained in the percolating water, reduces the very dilute solution; or it may happen that other salts are present in solution, which effect a precipitation of the iron. In this way the oxidation of the primary sulphides remains concealed to our eyes.

But there may exist some favorable conditions, producing the deposition of the secondary iron sulphates not far away from the original primary minerals, (pyrite, marcasite or chalcopyrite); so that the derivation is highly evident and instructive. Nevertheless such localities are not often met with.

Not far from Montpelier in Muscatine county, Iowa, is a locality, where this mineral-forming process with its products and accompanying effects can be observed. Leaving the train in Montpelier we follow the stony bed of a small creek, dry in summer and fall, walking over Devonian limestone, until after about one mile and a half we reach a locality, where the contact between Devonian limestone and overlying Carboniferous sandstone can be observed. The water of the creek has washed out and undermined the sandstone, so that the higher ledges are somewhat overhanging. At this locality I found the lower 3-4 feet of the sandstone incrusted with a yellow dry material of the color of natural sulphur or somewhat darker. The horizontal extension was about 40 feet and the thickness of the incrustation averaging 1-2 inches—altogether there was

a considerable amount of the material. In looking around, a few other localities, similar to this one could detected. The strata of the sandstone were a few degrees inclined towards the bed of the creek, so that all the water, percolating through the porous sandstone has its natural outflow into the creek.

Plenty of apparently pure material could be collected for analysis. The results of my analysis, made in the chemical laboratory of the Iowa State University, may be given as follows:

The mineral was readily soluble in cold water, leaving a very small residue insoluble in acids (Si O_2). In boiling the solution, a brownish floccular precipitate separated out, probably a basic iron salt, soluble in dilute hydrochoric acid and giving reaction for iron. Very small traces of alumina could be identified. The presence of sulphuric acid was identified in the ordinary way. The following is the average from two analyses:

SO_3	39.01 per cent.
H_2O	32.32 per cent.
Al_2O_3	0.27 per cent.
Fe_2O_3	26.86 per cent.
Insoluble residue SiO_2	1.79 per cent.
	100.25

Specific gravity was found 2.212 H = 2.5

If the small trace of alumina is calculated as iron, there results the following ratio:

$$SO_3 : Fe_2O_3 : H_2O = 2.87 : 1 : 10.5$$

or about $3 : 1 : 10$

corresponding to the formula $Fe_2(SO_4)_3 + 10\ H_2O$, i. e. the composition of the mineral is identical with quenstedtite.

Dana gives the following composition for quenstedtite:

SO^3	39.83 per cent.
H^2O	31.35 per cent.
Al_2O_3	trace
Fe_2O_3	27.66 per cent.
CaO	0.40 per cent.
	99.24

The determination of the water was made by Prof. Penfield's method and gave very exact and identical results.

The gradual loss of water at different temperatures was found to be as follows:

at 105°	loss of water	21.04 per cent.
" 110°	" " "	25.09 per cent.
" 130°	" " "	25.88 per cent.
" 140°	" " "	29.94 per cent.
" red heat "	" "	32.32 per cent.

The mineral is stable in the open dry air for about 5-6 months, but then it begins to decompose, gets white and crumbling.

A mineral which is so readily soluble in water can only be formed under very favorable conditions, and at this locality the conditions were so favorable that the mineral was deposited in relatively large quantities. The place was protected from rain by overhanging rocks and shaded by trees; for the mineral decomposes readily when exposed to the direct sunlight for a longer time. The strata are inclined towards the bed of the creek, underlain by the impermeable Devonian limestone, so that all the percolating water has its natural outflow just at this locality, making a concentration possible. The sandstone is porous and contains pyrite in an enormous quantity of finest scales. Percolating water and evaporization were in perfect equilibre at the time of my first visit. As Dana gives only one other locality where this mineral occurs, Tierra Amarilla, near Copiapo, Chile. I took interest to visit the locality again in April of this year. No trace of the mineral could be detected; only a small quantity of water of acid reaction and metallic taste was flowing out of the rock. When I visited the locality again in August, the deposit had reached its original thickness. It is the same thing as with the efflorescing salt of the desert, it comes and disappears, with respect to the season.

The rock coated by the quenstedtite is very much decomposed by the free sulphuric acid, formed by the oxidation of the pyrite.

$$2FeS_2 + H_2O + O_{15} - Fe_2(SO_4)_3 + H^2SO_4$$

INTRUSIVES IN THE INWOOD LIMESTONE OF MANHATTAN ISLAND.

By E. C. Eckel, New York.

(Plate III.)

The rocks of southeastern New York, according to Prof. C. R. Van Hise and Dr. F. J. H. Merrill, may be classified as follows:

ORDOVICIAN:

1. Manhattan schist—mica schist containing garnet, fibrolite, kyanite, and staurolite. Hudson River age.
2. Inwood limestone—crystalline dolomyte, containing diopside and tremolite. Calciferous-Trenton age.

CAMBRIAN.

1. Lowerre quartzyte.

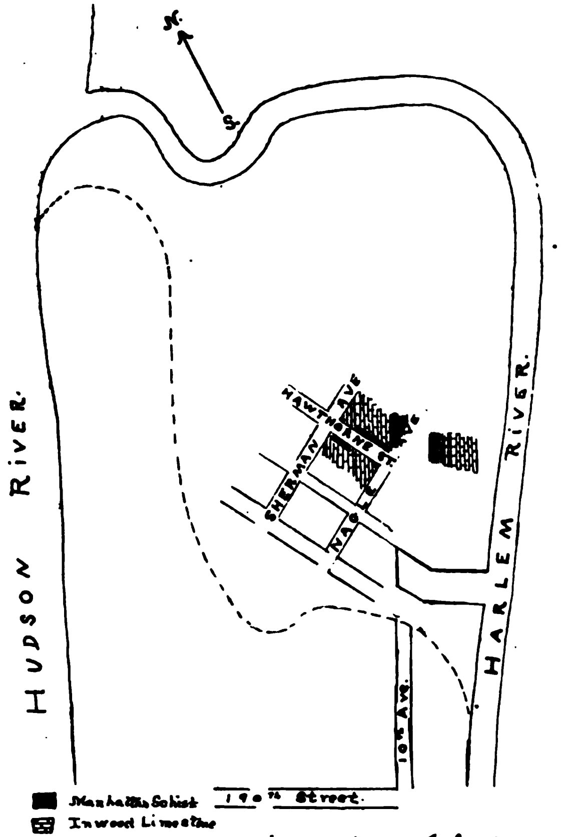
PRECAMBRIAN.

1. Fordham gneiss; Algonkian?
2. Granites and gneisses; Archæan?

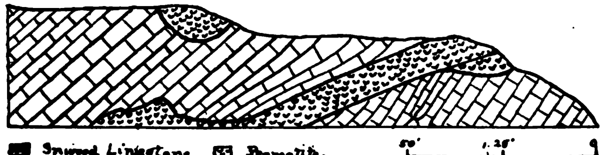
At a time beginning not later than the Upper Silurian, and possibly continuing at intervals to the end of the Palæozoic (F. J. H. Merrill), these strata were thrown into parallel folds having a general northeasterly trend. Transverse folding has resulted in a general gentle pitch to the southwest, and overthrown folds are common.

Of the formations mentioned above, the Manhattan schist and Inwood limestone form the surface or subsurface strata over the greater part of Manhattan island, though at one place a small extent of the Fordham gneiss is exposed. The Manhattan schist is everywhere cut by sheets and dikes of pegmatyte, but no intrusive has heretofore been described from the Inwood limestone of Manhattan island. The purpose of this paper is to describe one locality on the island at which such an intrusion is a very striking feature of the section. This occurs at Hawthorne street, between Nagle and Sherman avenues, a few blocks north of Fort George.

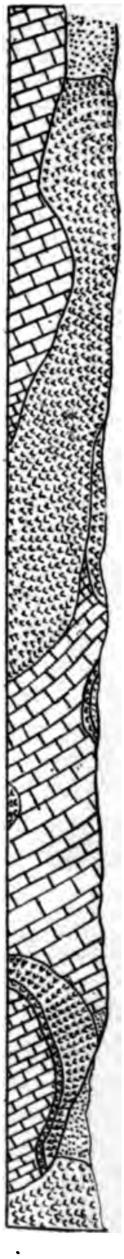
At this point the cutting for Hawthorne street has exposed, on both sides of the street, rock-sections twenty to thirty feet in hight and about seven hundred feet long. The entire section consists of the Inwood limestone and its contained intrusives. At the southerly corner of the east side of the street, however, gneiss is exposed. Continuing south toward the Harlem river, after an intervening drift covered surface, the gneiss is again met, and then limestone again becomes the surface rock. The relations of the gneiss and limestone will be recurred to later.



Map—Northern Part Manhattan Island. Black Lines show location of Sections. The dotted line shows contact between Inwood and Manhattan beds. Above that line the surface rock is usually Limestone; below it, schist



Cross Section of part of Westerly side Hawthorne Street.



Cross Section of part of Easterly side Hawthorne Street.

SECTIONS ON MANHATTAN ISLAND.

The limestone exposed on Hawthorne St. is a comparatively fine-grained dolomyte, with small amounts of a brown mica, and frequent crystals and incrustations and interlaminations of chalcopyrite. Tremolite is infrequent, although a block further east extremely large and fine crystals are common. Small veins and stringers carrying quartz, often in crystals, cut the limestone in many places. The limestone is distinctly and rather heavily bedded. The layers have a line of strike about 17° east of north, dipping about 30° to the east. The pitch is very high, being 30° to 40° to the southwest. The steepness of the pitch and the fact that the strike approaches more closely to the north than is common in this section, would seem to indicate that we are near the southerly end of a fold; on its westerly side. It will later be shown that this fold is probably synclinal.

As shown in the sections, the limestone is cut in several places by an intrusive. This rock is a coarse grained pegmatyte, consisting of quartz and orthoclase, with a very little muscovite. Black tourmaline is a rare accessory. At the north end of the western side of the street, a main sheet, six feet thick, of pegmatyte, gives rise to a large number of smaller stringers. In these, and in the adjoining limestone, brown tourmalines are developed, generally in radiated clusters. Though this occurrence is most distinct here, it is repeated to a greater or less extent at other contact points. The contact plane between limestone and pegmatyte is everywhere marked by the development in the former, for a depth of an inch or so, of small tremolite crystals and a great profusion of biotite in fine scales. These give a gray or greenish tint to the limestone in this narrow band.

The pegmatyte, in sheets varying from a foot up to twelve feet in thickness, cuts the limestone generally transversely to its bedding planes, but occasionally parallel to them. In all cases, however, the intrusive sheet follows very closely the pitching plane of the limestone. An exception to this rule may occur at the southerly end of the east side of the street, where a mass of pegmatyte, thirty feet in thickness, is exposed at the contact between limestone and gneiss. This mass has been so far excavated as to render difficult a determination of its exact form, and of its relation to the gneiss. The pegmatyte may enter the gneiss, but there is no clear proof that

it does. The absence of certain knowledge on this point is the more unfortunate because, were we sure that the intrusive did not penetrate the gneiss, it would go far toward establishing the age of this group of intrusions as post-Calciferous and pre-Hudson River. As it is, the relations of the pegmatyte sheets to the major and minor folds of the locality point toward the conclusion that the intrusion took place toward the close of the period of disturbance of the crystalline series.

As was stated in an earlier part of this paper, the materials passed over in following the general line of Hawthorne street southward to the Harlem river are, in order, after the Hawthorne St. limestone exposure,—gneiss, drift, a second outcrop of gneiss, and then a second outcrop of limestone. These last outcrops are in such a position that a determination of their dips is a matter of difficulty. I believe, however, that the gneiss nearest the river dips steeply to the east, and that the limestone adjacent to it is conformable. The gneiss is a black, highly garnetiferous, biotite gneissoid schist; its stratigraphical position leaves no doubt as to its being an outlying uneroded portion of the Manhattan schist.

These facts, taken together with the dips observed at the northerly limestone outcrop, would indicate that the two formations, limestone and gneiss, are here folded into a syncline, trending northeast and southwest, and crossfolded so as to give a pitch toward the southwest. This synclinal is overturned toward the west, as is shown by dips on both sides of its axis being in the same direction. My reasons for considering that this locality is on the southern border of the trough, and near the end of the syncline, are stated in an earlier part of this paper.

Throughout this region, in addition to difficulties arising from the extreme metamorphism and the complicated series of folds and cross-folds, relations are obscured by the extent to which the softer formations have been eroded, by both water and ice; and by the great depth of the terraced drift. Furthermore, buildings or other artificial structures may frequently be found covering critical sections. The growth of the city, especially in this direction, is so rapid that information regarding the geological structure of Manhattan island, unless collected soon, will be forever unobtainable.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Supplement till om Acerocarezonen, also *En trilobit från Skånes Dictyograptusskiffer*, af JOH. CHR. MÖBERG. (Geol. fören i Stockholm förhandl. Bd. 20, Hf. 5, 1898.)

These pamphlets by Dr. J. C. Möberg are an illustration of the thorough way in which the Swedes are working up the natural history and geology of their country. Not only are the Paleozoic faunas being fully elaborated, but the exact horizon at which the several species are found (so important for a proper understanding of the succession of living beings upon the globe) is being carefully determined.

The first pamphlet adds to our knowledge of the species *Acerocare claudicans*, *A granulatum* and *Parabolina heres*, which are described in the original article by this author and H. Möller on the Acerocare zone, especially the first species.

The second pamphlet describes a remarkable trilobite of the Dictyonema slates, heretofore devoid of trilobites, which is of interest as showing a curious combination of the characters of Cambrian and Ordovician trilobites. The species is supposed to be a new genus *Hystrolenus* and is named *H. tornqvisti*. It has pygidial spines like Ctenopyge and pygidial segments like Dicellocephalus. By the sculpturing of the glabella, the position of the eye, and the course of the facial suture it resembles Niobe. The author compares Hystrolenus to Asaphalina Mun.-Cham and Berg., which he considers the most nearly related genus.

Each of these articles is accompanied with a plate showing parts of the various species described. G. F. M.

Topaz crystals in the mineral collection of the U. S. National Museum. By ARTHUR S. EAKLE. (Proc. U. S. Nat. Museum, vol. 21, pp. 361-369 [No. 1148], 1898.)

This article describes the crystals of this attractive mineral included in the Museum collection. The forms occurring on the crystals from the different localities are listed and illustrated by figures, and in some cases forms not hitherto reported from certain localities are noted, but no forms new to the mineral were found. U. S. G.

Distribution of Metallic wealth in Arizona. W. P. BLAKE, territorial geologist, [included in the report of the governor of Arizona for the year ended June 30, 1898].

This report gives, along with a birdseye view of the location and extent of the main mining belt, which is a mountainous tract extending from N. W. to S. E. across Arizona a distance of nearly 500 miles, many special facts of interest, and some geological notes of broader significance, and a summary of economic mineralogy not metalliferous. It is a report that cannot fail to interest both geologists and miners, as well as capitalists who are seeking information concerning Arizona. N. H. W.

The Cretaceous Foraminifera of New Jersey. By R. M. BAGG, Jr. (Bull. U. S. Geological Survey No. 88, 8°, 89 pp., 6 pl., 1898.) American literature is conspicuously deficient in works relating to the fossil Foraminifera, although in Europe the class has received the attention of some of the leading paleontologists and their monographs and special reports cover the investigations of many years.

The present memoir covers the Cretaceous Foraminifera from the marl beds of New Jersey, including the Monmouth, Rancocas and Manasquan formations. The greatest number of species, (seventy-nine) occurs in a limestone layer in the Rancocas formation. Four species are common in all four marl beds. Altogether there are one hundred and fifteen species now known from the New Jersey Cretaceous. The plates give unusually good representations of the form and structure of about thirty species of special interest. C. E. B.

Recent Earth Movement in the Great Lakes Region. By G. K. GILBERT. (U. S. Geol. Survey, 18th Ann. Rept.. pt. 2, pp. 595-647, pl. 105, 1898.)

As has been known for several years, the abandoned beaches of the Great Lakes region give undisputed evidence of a decided tilting of the land surface in a south-southwesterly direction since the retreat of the last ice sheet. Mr. Gilbert has collected the evidence on the question, is this tilting still in progress?

He first calls attention to a paper by Mr. G. R. Stuntz, presented before the American Association for the Advancement of Science in 1870, in which occurs the first broaching of the idea of differential uplift in the Great Lakes region. Then the earth movement in this district during the closing epochs of the Pleistocene and the reasons for regarding a modern change as probable are discussed. After this comes a detailed description of the methods used in making measurements for the present determination. In brief this determination is made by comparing the difference of elevation of the water at one point of a lake's surface with that at another, as shown by reference to fixed bench marks, and then after a period of years another comparison is made to show whether there has been a change in the position of the water surface. The data for these measurements were obtained largely from the records of the United States Lake Survey. Four pairs of stations were selected, and these, with the years in which the measurements were made, are as follows:

Lake Ontario, Charlotte and Sacketts Harbor, 1874 and 1896.

Lake Erie, Cleveland and Port Colborne, 1858 and 1895.

Lake Michigan-Huron, Milwaukee and Port Austin, 1876 and 1896: and Milwaukee and Escanaba, 1876 and 1896.

By reducing the results obtained from these stations to the assumed direction of the tilting (S. 27° W.) and eliminating as far as possible all sources of error, it was found that the tilting amounted to 0.42 foot per one hundred miles per century. This is the mean of the determinations. Concerning the question at issue the author says:

"With the numerical results of the investigation before us we may now recur to the main subject and ask whether the evidence warrants the conclusion that a general, gradual tilting of the basin is in progress. In the discussion of the data used in comparing the several pairs of stations it has been found that, taken at their face value, they indicate a tilting in the hypothetic direction, but it has also been found impossible to resolve all doubts as to the stability of the gages and benches and the accuracy of the measurements. By reason of these doubts the result from no single pair of stations is conclusive, but when assembled they exhibit a harmony which argues strongly for their validity. * * * Not only do all these results indicate a change of the same sort, but they agree fairly well as to quantity. The computed change for 100 miles in a century ranges only from 0.37 to 0.46 foot, and the greatest deviation of an individual result from the mean is 12 per cent. This measure of harmony appeals strongly to the judgment, and is also susceptible of approximate numerical expression."

"It seems to me that the harmony of the measurements and their agreement with prediction from geologic data make so strong a case for the hypothesis of tilting that it should be accepted as a fact, despite the doubts concerning the stability of the gages."

The geographical changes resulting from this earth movement are outlined. Chief among them is the reversal of the drainage of the Great Lakes, causing the outlet to be by way of Chicago and the Illinois river. Attention is also called to a paper by Mr. E. L. Moseley in which evidence for the sinking of the land, or the rising of the water, near the west end of lake Erie is presented. Mr. Gilbert offers a plan for the taking of further and more accurate observations in regard to the tilting of the land in this district, and it is greatly to be hoped that some agency, preferably one of the scientific bureaus of the government, will undertake this interesting investigation.

U. S. G.

Physical Geography. By WILLIAM MORRIS DAVIS, assisted by WILLIAM H. SNYDER. Small 8vo, pp. 428, $1.25. Boston: Ginn & Co., 1898.

One occasionally hears the complaint made that physical geography is not a proper subject for the public school curriculum. The complaint alleges that the subject is lacking in continuity; that it is merely a disconnected and often misleading mass of facts gathered here and there from a number of other sciences; that aside from the information given it has little or no educational value because of the lack of a great underlying principle to bind the facts together and give unity to the subject.

However great our enthusiasm for the subject may be now, we are bound to admit that until a few years ago such charges had some basis in fact. The average text-books on the subject have too often been little more than loose descriptions of isolated facts, sometimes lacking even in systematic arrangement.

Such a condition is not at all surprising. The systematic study, in detail, of the earth's surface is a relatively recent thing. Differences

in land forms were seen but they were described as isolated and fixed facts. Until geologists had shown that the earth's surface is not a finished product but is only one of a long series of conditions produced by the action of continuous forces, acting in cycles; that it is the expression of the action of force on matter just as much as is the form of any organism, the descriptions had to be arbitrary and irrational.

The recognition of this relation, however, makes the earth's surface the product of evolution. The idea of development through living processes binds the facts together into a unified whole. The subject becomes the study of the life of the earth.

The systematic result of long and continuously acting processes does not end with the mere evolution of the land surface. The condition of man, of his industries, commerce, comforts, in a word, his civilization, is as much the result of the land he lives on and the air he lives in, as these are the result of the earth's vital forces. Physical geography thus becomes a study in evolution.

Such a unifying idea pervades the book before us. Those who are accustomed to look for the result of thorough digestion and careful analysis in a work from Prof. Davis' pen will not be disappointed in this. At every step it shows careful consideration. It is the matured fruit of years of class-room work in the subject. The order of discussion is logical; the space given to the different divisions of the subject is fully in accord with their importance, and the relation of man to the many features described is carefully considered and fully brought out in both text and illustrations. That part of the book in which land form is discussed is a clear statement of the principles of the evolution of land form, illustrated by full references to, and careful descriptions of, actual forms selected from many parts of the world.

The first chapter deals with a few of the more striking cases in which man is profoundly influenced by his surroundings. Chapter II considers the earth as a globe. It is concerned chiefly with the size and shape of the earth and the usual heavenward excursion by the imagination is wisely omitted.

The atmosphere is discussed in the space of 40 pages in the next chapter. The treatment is mainly descriptive and no knowledge of physics is presupposed. After describing the distribution of atmospheric temperature and pressures, atmospheric dynamics is discussed under the heads of the ideal planetary circulation, and terrestrial circulation; then cyclonic disturbances and their consequences follow, under several sub-headings.

The ocean is next considered in a chapter of 30 pages. The main features of distribution, depth, temperature, composition and character of bottom are briefly described. The consideration of the tides is brief and descriptive.

The rest of the book is devoted to the discussion of the forms of the land. One short chapter deals with general considerations such as changes, area and hight of the land, continental outline, varieties of rock, wasting of the land and life on the land. This chapter within

a space of 20 pages, dismisses the subjects which constituted the greater part of the consideration of the land in the text-books ten years ago. Of the 400 pages in the text, excluding appendixes and index, 290 are devoted to the discussion of land forms. Plains and plateaus are considered at some length, beginning with coastal plains, which are traced through their development from the young plain bordering the sea coast, to the old ones now situated far within the continental border.

In this chapter, that on "Mountains," and one on "The Waste of The Land," the evolution is traced by describing typical forms in various stages of development with reference to, but not discussion of, the processes of evolution. In the chapters on "Rivers and Valleys," "Shore Lines" and that part of chapter XI relating to glaciation, the processes are described along with typical forms produced by them.

There are a number of appendixes and a full index. Among other things, Appendix L gives many references to the literature of the subject which will be of great value to teachers. The descriptions and explanations are clear and sufficiently simple for pupils of high school grade. Unusual technical terms are almost wholly absent. The book is fully illustrated with clear and appropriate maps and photographs. It is of convenient size, is clearly printed on good paper and is well bound. It is incomparably the best text on the subject yet issued.

C. F. M.

MONTHLY AUTHORS' CATALOGUE
OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

[Baur, George.]

George Baur's life and writings. By W. M. Wheeler. (Am. Nat., vol. 33, pp. 15-30, portrait, Jan. 1899.)

Carpenter, L. G.

Losses from rivers. [Abstract.] (Proc. A. A. A. S., vol. 47, pp. 246-247, Dec. 1898.)

[Cope, E. D.]

Edward Drinker Cope. By H. D. King. (Am. Geol., vol. 23, pp. 1-41, pl. 1, Jan. 1899.)

Crawford, John

Recent severe seismic movements in Nicaragua. [Abstract.] (Proc. A. A. A. S., vol. 47, p. 299, Dec. 1898.)

Crosby, W. O.

History of the Blue Hills complex. [Abstract.] (Proc. A. A. A. S., vol. 47, pp. 304-305, Dec. 1898.)

*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Dall, W. H.

On the present state of our knowledge of the North American Tertiary mollusk-fauna. [Abstract.] (Proc. A. A. A. S., vol. 47, p. 361, Dec. 1898.)

Dall, W. H.

A table of the North American Tertiary horizons, correlated with one another and with those of western Europe, with annotations. (U. S. Geol. Survey, 18th Ann. Rept, pt. 2, pp. 323-348, 1898.)

Davis, W. M. (assisted by Snyder, W. H.)

Physical geography. (xviii and 428 pp., 9 pls.; Ginn and Co., Boston, 1898.)

Davison, J. M.

Platinum and iridium in meteoric iron. (Am. Jour. Sci., ser. 4, vol. 7, p. 4, Jan. 1899.)

Eastman, C. R.

Some new points in dinichthyid osteology. [Abstract.] (Proc. A. A. A. S., vol. 47, pp. 371-372, Dec. 1898.)

Ehrenfeld, Frederick.

A study of the igneous rocks at York Haven and Stormy Brook, Pa., and their accompanying formations. (Thesis presented to the faculty of the department of philosophy of the University of Pennsylvania, in partial fulfillment of the requirements for the degree of Doctor of Philosophy. 24 pp., 1 pl.; Avil Printing Co., Philadelphia, 1898.)

Emerson, B. K.

Outline map of the geology of southern New England. [Abstract.] (Proc. A. A. A. S., vol. 47, p. 291, Dec. 1898.)

Fairchild, H. L.

Glacial geology in America. (Proc. A. A. A. S., vol. 47, pp. 257-290, Dec. 1898.)

Fairchild, H. L.

Basins in glacial lake deltas. [Abstract.] (Proc. A. A. A. S., vol. 47, p. 291, Dec. 1898.)

Fowke, Gerard.

Pre-glacial drainage in the vicinity of Cincinnati; its relation to the origin of the modern Ohio river, and its bearing upon the question of the southern limits of the ice-sheet. (Bull. Sci. Lab. Denison Univ., vol. 11, pp. 1-10, pl. 1, Mch. 1898.)

Gallaher, J. A.

Biennial report of the bureau of geology and mines, state of Missouri, 1898. Jno. A. Gallaher, state geologist. (68 pp.; Jefferson City, 1898.)

Geraland, Georg.

Modern studies of earthquakes. (Appletons' Pop. Sci. Monthly, ol. 54, pp. 362-371, Jan. 1899.)

Goodwin, W. L., and Miller, W. G.

Note on a mineral of the columbite group. (Jour. Federated Canadian Mining Inst., vol. 3, pp. 151-152, 1898.)

Grabau, A. W.

Paleontology of the Cambrian terranes of the Boston basin. [Abstract.] (Proc. A. A. A. S., vol. 47, pp. 305-306, Dec. 1898.)

Grimsley, G. P.

Kansas mineral products. (11th Bien. Rept. Kansas State Board of Agriculture, pt. IV., pp. 497-523, 1898.)

Gwillim, J. C.

Some West Kootenay ore bodies. (Jour. Federated Canadian Mining Inst., vol. 3, pp. 19-26, 1898.)

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CORRESPONDENCE.

KANSAS UNIVERSITY GEOLOGICAL SURVEY. My attention has recently been called to a review (?) of Volume III, of the University Geological Survey of Kansas, published in the December, 1898, issue of the GEOLOGIST and signed by one C. R. K. As the article shows so plainly that it was written to vent a personal animosity rather than to let the readers of the GEOLOGIST know what Volume III contains, I beg leave to say to your many readers that our University Geological Survey has published four volumes and has Volume V now in press, all of which are for free distribution. The edition of Volume I, however, has been exhausted for nearly a year, but a supply of the others is still on hand. We would be glad to send any or all of them to any one interested in them sufficiently to pay the postage or express. The postage on Volume II is 24 cents; Volume III, 28 cents; Volume IV, 32 cents.

ERASMUS HAWORTH.

Lawrence, January 20, 1899.

PERSONAL AND SCIENTIFIC NEWS.

INTERNATIONAL CONGRESS OF GEOLOGISTS.

The eighth session will be held in Paris, August 16th to 28th, 1900, in connection with the Universal Exposition of 1900. The French geologists have gone into the idea of the congress with enthusiasm and a committee of organization has been constituted; this committee has already held several meetings; M. Albert Gaudry is president, MM. Michel-Lévy and Marcel Bertrand vice presidents, and M. Charles Barrois general secretary. The meetings of the congress will be held in a special pavillion of the exposition, and the length of the session will permit the members of the congress to visit the exposition and geological museums of Paris. A large number of excursions to points of geological interest will be arranged for. The preliminary list shows three general excursions, which it will be possible for a large number of persons to attend, and nineteen special excursions, which are reserved for specialists and on each of which it will be possible for no more than twenty persons to go. The plans of the different excursions form the subject of a circular which will be sent out in 1899, and a summary guide book, written by the directors of the different excursions, will be placed on sale at the beginning of 1900.

THE SEVENTH INTERNATIONAL GEOGRAPHICAL CONGRESS will be held in Berlin, Sept. 28 to Oct. 4, under the auspices of the Gesellschaft für Erdkunde zu Berlin. Before and after the congress excursions will be arranged through such

parts of Germany as may be of interest in regard to physical or economic geography. An excursion to Hamburg, by invitation of the Geographical Society of that city, is especially contemplated. Those who intend to read papers at the congress are requested to notify the secretary before April 1. The membership fee is 20 marks. The address of the officers of the congress is 90 Zimmerstrasse, Berlin S. W.

Dr. H. C. Hovey, of Newburyport, Mass., gave an illustrated lecture on the Region of the Causses in France, January 30, before the section of geology and mineralogy of the New York Academy of Sciences, at the rooms of the American Society of Mechanical Engineers, New York.

Ward's Collection of Meteorites. Under date of December 10, 1898, Prof. H. A. Ward writes from Teheran, Persia, "The only cause which I can give for coming clear up here from the Caucasus and the Caspian is my getting enamored of a meteorite (the Veramin) which I have known for some years as being in the possession of His Majesty the Shah. This I have found and I have spent the last two days in cutting off a fair sized piece for my collection of meteorites, which collection I am increasing by this Europe-Asiatic trip by over one hundred falls."

The Geological Society of London is about to publish the manuscript in its possession of a portion of the third volume of Hutton's "Theory of the Earth." It has been edited and prepared for the press by Sir Archibald Geikie. The third volume will be printed in the style of the first and second volumes of the same work, and will contain about 300 pages. It will be issued in paper covers. The price will be, to fellows of the society, 2s.; to the public, 3s. 6d.. Only a limited number of copies are to be issued. Subscriptions may be sent to the secretary of the Geological Society, Burlington House, W.

The Work for Prof. Crosby's Memoir on the geology of the Boston Basin has been completed through the Blue Hills, which are to form the third volume. The paper is now waiting for a few rock analyses of the intrusives. Dr. T. G. White, of Columbia University, did the petrographic work, and Mr. A. W. Grabau, of Harvard University, wrote the part on the glacial lake Bouvé, which is included within the bounds of this memoir. For the fourth volume, which will take up the region west of the Blue Hills, the Neponset and Hyde Park district, Prof. Crosby is to have the assistance of Dr. Bascom in the petrographic work.

Dr. A. S. Eakle, of Harvard University, is beginning a chemico-petrographical study of the igneous rocks of the Boston Basin, similar to that which Dr. Washington has undertaken for those of Essex county Mass.

James Hall

THE

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THE LIFE AND WORK OF JAMES HALL, LL. D.

By HORACE C. HOVEY, D. D., Newburyport, Mass.

(Plates IV and V.)

On professor Hall's sixtieth anniversary as state geologist, an incident was given showing his readiness to aid others. A friend of his has asked me to repeat the facts, which may be done by way of introduction to this article, showing partly why at the request of the editor of this magazine it was undertaken.

My father, the late Prof. E. O. Hovey, D. D., of Wabash College, was a pioneer in geology, at least so far as Indiana is concerned. He took his chair in 1835, and found himself surrounded by rich beds of fossiliferous limestone that fitted no classification then existing. In my boyhood I found what the Hoosiers called "Indian beads," and "petrified toads." These of course were crinoidal stems and heads, mostly from Corey's bluff (now my property), whence at a much later period Bassett, Bradley, and others, quarried literally thousands of crinoids for the principal museums of this country and of Europe. Prof. Newberry, of Cleveland, whom Hall had fired with enthusiasm, wrote offering me five dollars for a bushel of the so-called "Indian beads." He got his bushel and sent the money, but did not repeat the order. Newberry told Hall of this, and an agreeable correspondence was thus begun.

In 1853 we visited Albany, and exhibited our crinoids, which Hall asked permission to examine and describe. Afterwards he sent his expert assistant, Mr. R. P. Whitfield, to visit the region. In 1856 Hall read a paper before the Albany Institute, describing new Indiana fossils, followed by other pa-

pers of later date. In 1862 he gave me for Wabash College, a full set of his voluminous publications, and a complete suite of New York fossils, carefully labeled. Owen, Cox, Collett, and other Indiana geologists, testify to his readiness to help men struggling with new scientific problems.

James Hall was born, September 12th, 1811, of parents who came over from England early in the century and settled at Hingham, Mass. His father was a silk weaver, and from all accounts was a man of strong likes and dislikes, and was lion-like when aroused by opposition; in which respect his distinguished son somewhat resembled him. Urbanity is not always possible amid untoward circumstances. I remember to have heard him say that his parents were poor; and he added with marked emphasis, "A geologist must dare to be poor." I do not know that he meant that he should stay so if he could help himself. There is a tradition that he used to walk from Hingham to Boston to hear lectures on natural history and walk back again at their close. But the fact is that he rarely spoke of his boyhood, outside the home circle, though it is doubtful if he had many incentives to study in the direction of what afterwards became his life-work. His early bent seems to have been toward the medical profession, and he had the degree of M. D. from the University of Maryland after he had begun to win fame as a geologist.

He was graduated in 1832 from the Rensselaer School at Troy, since made a Polytechnic Institute; and while there he came under the stimulating influence of Prof. Amos Eaton, who aroused his zeal for the natural sciences. Hall became associated with him in teaching, and was for a series of years a geological professor in the Institute. Eaton had reconnoitered through the unexplored regions of New York, had lectured to the Legislature on the subject of geology, and is said to have actually set governor Clinton to collecting fossils. He was largely instrumental in creating the state survey, and both he and Mr. Stephen Van Rensselaer, who did so much by his far-sighted liberality to make such explorations successful, wished Hall's appointment at the outset as one of the four chief geologists. But the governor thought he had better take a subordinate place at first mainly if not altogether on account of his youth. His friends did not lose sight of him; and we remem-

ber that when, at the Buffalo celebration, in 1896, congratulations and compliments rained on the veteran man of science, he modestly said that he owed most of his success to Stephen Van Rensselaer.

On the organization of the state survey, in 1836, Hall was appointed assistant of Dr. Ebenezer Emmons, in the Adirondack region, of what was then the Second District. Singularly both Hall and Emmons, in their publications, ignore that first season of official life, and we can only conjecture that it must have been a period of activity. In 1837 he was appointed by governor William L. Marcy as state geologist of the Fourth District, which had been in charge of Vanuxem, who was transferred to the Third. For certain reasons the original apportionment of the four districts had not pleased the geologists. The choice of a young man, twenty-five years of age, for such an important field, was in itself remarkable: but still more so was the report made by him on the Fourth Geological District, so exhaustive, conscientious, discriminating, and withal so influential on all similar works from that day to this.

Without the formality of quoting we avail ourselves of the observations made by his associates concerning this volume, that set the name of James Hall at once in the front rank of geologists. The district happened to offer no very complicated problems, nor intricate topography. The formations are extremely regular, and the water-course, lake basins and highlands obey the laws that made them with marked uniformity. Such simplicity made certain results more easy of attainment, leaving the investigator free to gather details of valuable knowledge that might otherwise have been impracticable.

Then again, the easily accessible lowlands, where the principal settlements had been made, had also the majority of the distinct formations, such as the Medina, Clinton, Corniferous, Waterlime, Marcellus and Hamilton. Half the district was, in 1837, a wilderness of uplands divided between the Portage and Chemung.

Eaton and other American geologists had been using European classifications, and Hall tried to correlate the New York formations with those described by Murchison and Sedgwick, but found it necessary to classify them independently,

and thus set the standard for American geology and, in a sense, became its founder. Official surveys of other states refer to the splendid volumes of the New York survey, brought out by Hall, Emmons, Vanuxem, Conrad, Mather, Torrey, DeKay, Beck, and others, as the criterion of accuracy, in preference to the best productions of foreign lands.

"The New York geologists have made out a classification of their older rocks," was the challenge of Sir Charles Lyell, "now let them prove the truth of it by means of their fossils." This reasonable demand stimulated Hall to give increased prominence to the study of paleontology, with brilliant results known to the whole scientific world. We do not forget his associates, from whose work in stratigraphy and nomenclature it is not easy always to mark a line of distinction, but it does them no injustice to regard Hall as the founder of "the New York system," the main features of which have been generally applicable in the United States. Most of the names adopted are in current use, e. g., Trenton, Utica, Medina, Clinton, Niagara, Marcellus, Hamilton, etc. These are "type-localities," admitting modification as applied to regions similar, if not exactly identical; and this elasticity has made the system more useful than certain other inflexible ones that were for a time its rivals.

Cartographic methods were extremely imperfect when Hall took his place as chief of the New York survey. Much of the state was inaccurately surveyed, and even several decades passed before this hindrance was overcome. Evidently geologic mapping needs a trustworthy topographical basis. Official obstacles caused delay. Wide regions lay hidden under forests and recent deposits that made it hard to do more than shrewdly guess at the underlying rocks. After materials had been slowly accumulating for fifty years, Prof. Hall was aided by Dr. W J. McGee in the interpretation of the records thus toilsomely gathered; a base map was compiled, geological explorations revised, new ones made with a degree of vigor hardly to be looked for from an octogenarian, such as Hall had become, and at last, 1896, a proof edition was printed mainly as a stimulus to further research. But even in this confessedly incomplete form, the geological map of New York meets the standard of excellence better than anything else of the kind in this country,

and whatever aid may have been had from assistants, its real author is the man whose varied and remarkable labors are now recounted.

A most exemplary feature of Prof. Hall's public services does not seem to have been sufficiently remarked even by his eulogists, and that is his zeal in helping practical men to develop the resources of their commonwealth. He did not forget, amid his enthusiasm for fossils and gems and maps, the needs of the miner, the quarryman, the potter, the brick-maker, the dealer in salt, cement, petroleum, and other materials contributing to the wealth of the State. Could the facts be obtained we should discover that the public had been thus repaid many times over for all that the survey ever cost. To persons of an economical turn of mind the sumptuous quartos that have followed each other in long array, at a total cost of at least a million and a half of dollars, have been ornamental rather than useful; and it is notorious that in every Legislature there are those who are prejudiced against such expenditures, and in many instances even governors have publicly taken credit to themselves for their opposition to what they deem scientific extravagance. And yet when one considers the utility of the discoveries made during the life of one such servant of the public as Dr. Hall the wisdom of the required outlay is unquestionable. Criticism is misdirected that blames the zealous geologist who pulled every string of influence necessary in order to accomplish so noble an end, who good-humoredly and persistently stuck to his purpose till it was gained, and who sacrificed personal comfort, needed rest, and more than once his individual resources, rather than relinquish the privilege of discovering and making known the natural resources of the Empire State. In this respect he perhaps had no equal.

Prof. J. J. Stevenson has called attention to certain unwritten chapters that prove Dr. Hall's remarkable fidelity to the interests of the Commonwealth and unselfish devotion to his work. And during his lifetime the latter assured his friends that these statements were correct. It seems that, in 1845, the geologists had to give up their rooms in the old State hall. Prof. Hall proceeded immediately to erect an edifice near his own residence for the purpose of carrying on his work, and still another larger building in 1856, at his own expense, and

for twenty-seven years the State made no allowance for his office rent and incidental expenses, until it was done in 1871. Between 1856 and 1866 appropriations were made for the cost of collecting new material; but prior to that this outlay was entirely at his own expense, and afterwards the appropriations were meagre. For five years, namely, from 1850 to 1855. salary and current expenses were absolutely withheld by the Legislature, and yet Hall retained his assistants and continued the work of the survey bearing nearly the entire expense, thus exhausting his resources and incurring serious indebtedness. His only way out was by selling at a sacrifice 2,000 acres of valuable coal and iron lands in southern Ohio, for which he got only $15,000, and which ten years later were held at $200,000.

It is not to be forgotten that, still retaining his work at Albany, Prof. Hall became interested in researches elsewhere. His report on the survey of Iowa was, and is, a standard authority for the West. The results appeared in a published form in 1858 and 1859. His work in Wisconsin was particularly valuable, the official report being printed in 1862 and 1864, covering what was done from 1859 to 1863. At its close the State was in arrears with him to the amount of $4,000, of which Hall accepted seventy per cent in fossils that he himself had collected, only $1,200 being paid in cash.

The name and fame of James Hall are so identified with New York as to make it necessary for us to remind ourselves of the breadth and scope of his explorations outside its limits. He was more or less connected with Fremont's exploring expedition; Stansbury's expedition to the Great Salt lake; the United States and Mexican boundary survey; the geological exploration of the fortieth parallel; the geological survey of Canada; and is said to have fitted out at his own expense the Meek and Hayden expedition to the Black hills.

A list of Hall's published works is appended to this article, naming 42 books, and 260 magazine articles and addresses before scientific associations. A glance at this formidable catalogue brings before the eye the names of Ohio, Indiana, Illinois, Michigan, Minnesota, Nebraska, Kentucky, Tennessee, Georgia, Alabama, Vermont, Pennsylvania, Wisconsin, Iowa, and Connecticut—fifteen states besides New York. The list also includes numerous special papers on new genera and

species of ancient fauna and flora from all parts of the world. How admirably was such a man fitted to make the address that he did as president of the American Association for the Advancement of Science, on the "Geological History of the American Continent;" originally given at Montreal, and afterward substantially repeated at Albany and in New York city.

Soon after Sir William Logan began the survey of Canada, in 1843, he opened communication with Dr. Hall and his associates, and from the first based the investigations of British America on the "well-founded classification of the rocks of the state of New York," and "practically without change of plan or nomenclature." In 1854 Hall examined the Graptolites of the Quebec group, and in 1855 the Devonian rocks of Ontario. For reasons already intimated he was at this time on the point of devoting himself wholly to the Canadian survey, as he was urged to do by a special committee of the Legislative Assembly. At this crisis, and at the suggestion of the secretary of state, Hon. Elias Leavenworth, a conference was held, attended by Prof. J. D. Dana, Prof. Louis Agassiz, and others, Sir William Logan being present, and also Mr. Blatchford, chairman of the Assembly committee of ways and means. The result was an agreement confirmed by the New York Legislature, that enabled Dr. Hall to prolong his work according to his original plan for the remainder of his life. Yet he always retained his interest in Canada, and freely put at the disposal of Sir William Logan materials that, as Logan himself says, made Hall responsible for half the completed geological map of Canada. When a biographical notice of the great American geologist was desired for Appleton's Cyclopædia, in 1874, it is noteworthy that the task was put in the hands of Dr. T. Sterry Hunt, of Montreal, and that at Hall's sixtieth anniversary of public service one of the most glowing tributes to his success came from Dr. George M. Dawson, director of the geological survey of Canada. Only a man of intense activity, energy and devotion to science regardless of territorial limitations, could have thus won the gratitude of the whole hemisphere.

Many of our most distinguished men of science have testified that they had their first impulses in the direction of geological investigation from him who has been so fitly styled "the

Nestor of American geology." A few instances may be cited of the many that could be given. In 1841 Dr. Hall made a trip to the Mississippi valley, and stopped for a while at Cuyahoga Falls, Ohio, as the guest of Mr. Newberry, whose son was amusing himself by collecting the coal-plants found in the shales of his father's mine. Before the visit ended young Newberry had decided to devote his life to the study of geology. In 1850 a pupil of Louis Agassiz went with Hall amid the Helderberg mountains, and took his first field lesson in geology; his name was Joseph LeConte, afterward professor of the University of California. Prof. R. P. Whitfield, now the paleontologist of the American Museum of Natural History, and famous for his many contributions to science, was for eighteen years Hall's assistant. F. B. Meek, the great authority on the Jura and Cretaceous on this continent, was also associated with Hall. So have been C. A. White, J. D. Whitney, C. D. Walcott, C. E. Beecher, John M. Clarke, and others eminent as geologists.

Reference, however brief, should also be made to the fact that when Hall took charge of the Fourth District of the New York survey, Mather had the First, Emmons the Second, and Vanuxem the Third. Conrad, who was the paleontologist of the survey, is said to have remarked as he retired from the field: "If I were to work a hundred years I could not describe the fossils of New York." This reminds us of Hall's own remark to Clarke when the last proofs of the last quarto volume had been read embodying the results of seven consecutive years of hard work on the paleozoic Brachiopoda: "We have labored very hard on this book, and have brought out some knowledge that will be useful to the scientific world; but for my part, I feel that I would now like to begin the study of the Brachiopoda." And this, again, reminds us of the confession of Sir Isaac Newton as to the incomplete nature of his wonderful work: "I seem to myself to have been only like a boy playing on the sea shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me." Such is the modesty of true greatness, caused by the consciousness that the greater the work actually done, the more vast appears what remains to be done.

DR. HALL IN RUSSIA.
1897.

THE AMERICAN GEOLOGIST,
Vol. XXIII, Plate V.

A reminiscence by LeConte is interesting. Hall spoke on the formation of mountains by sedimentation. His ideas were so utterly new to the geologists that there was no room for its lodgment in their minds. The audience of savants was bewildered. Guyot whispered to LeConte, "Do you understand anything he is saying?" "Not a word," was the reply. And yet the theory then advanced has been since fully developed into what is known as "The American theory of mountain- making."

Early attempts to promote science by associations of scientific men were experimental, and some of them short-lived. In 1839 the geologists of the New York survey met in Albany, Hall being chairman, to discuss what was organized in 1840, as the Association of American Geologists, which held its first meeting that year in Philadelphia. Without tracing anew its familiar history, we may claim that in due time its administrative offspring was the American Association for the Advancement of Science. In the act of incorporation Hall's name stands fourth in the honored list of founders; and he was its tenth president, holding that office in 1856, at the Albany meeting, when the famous Dudley Observatory was dedicated, Hon. Edward Everett giving the oration. Probably no person took a warmer interest than he in the annual meetings of the Association; and his ovation at the Buffalo meeting, in 1896, when an entire day was devoted to his praise, proves that his regard for his fellow-scientists was reciprocated. It is well known that he looked forward with keen anticipation to the Boston jubilee, in 1898, he being, with one exception, the sole survivor of the eighteen who formed the Association of American Geologists, and one of the six survivors of those who founded the American Association for the Advancement of Science.

Professor Hall left Albany early in last July, in his usual health, for a summer sojourn at the Echo Hill house, in the White mountains near Bethlehem, N. H., a locality where he had been in former years. Shortly after his arrival he had an attack of indigestion, which induced irregularity in the action of the heart. He rallied slowly and was advised by his physician at Albany to remain where he was. The local physician, at Bethlehem, is understood to have warned him that his con-

dition was precarious, and doubtless he fully realized that he was nearing his end. But in letters written even a day or so before his death, possibly on the very last day, not a word escaped him as to the outlook. He dropped dead. without further premonition, on Sunday, August 7th, 1898, just a fortnight previous to the Boston meeting where he would have been so heartily welcomed. The funeral was held at Albany, on the 15th instant, the services being in the Roman Catholic cathedral, though the remains were interred in the Protestant cemetery.

When, a year previous to his death, the International Congress of Geologists held its seventh triennial session in St. Petersburg, the place of special honor was accorded to James Hall, as "ancien president honoraire." He was the one chosen to represent the United States at the reception given by his imperial majesty, Nicholas II, to delegates from the twenty-four nations included in the congress. Again and again he was called on for speeches at the numerous banquets that were given by the cities and provinces through which excursions were made. Hall invariably spoke in English, deeming that language as worthy of recognition, though French was the official language of the congress. His speeches were short, appropriate, and always received with applause, especially by the Russians, for whose benefit they were translated, and with whom he was a universal favorite.

It was the writer's almost daily privilege to note with national pride the multiplied attentions paid to our veteran; and also to observe his ready response to greetings from the mujiks or the nobility, and his equaly affable answers to the queries of students or savants. It was a very long journey for a man of his years, even with every facility, and the unwearied kindness of his daughter, Mrs. Josephine Hall Bishop and her two sons, who accompanied him. The trip from New York to Moscow alone is 5,000 miles. Then there was the excursion to the Ural mountains, across the Asiatic boundary and back again, covering 1,900 miles by rail, with numerous side-trips by droskey, boat, or a-foot. Then came the voyage of 1,000 miles down the Kama and Volga; the sight-seeing at Nijni-Novgorod; the session of the international congress at St. Petersburg; followed by the extended excursions through southern Russia, and home again to America.

Besides the regular traveling there were the explorations of the peculiar Russian formations, some of which are truly geological puzzles; the visiting of quarries, mines, foundries, factories and museums, in all of which our octogenarian manifested as lively an interest as most of his younger comrades. Almost the only tasks he excused himself from were those of mountaineering, and of descending deep mines. It was marvellous to see the vigor of that man who had spanned already more that fourscore years of an extraordinarily busy and laborious life!

Hall's lasting memorial is in what he did for New York, and through New York for North America. For ages to come his name will be associated with our stratigraphy so that the latter cannot be historically described without the former being mentioned. Encircling the vast region lying east of the Rocky mountains are those massive rocks first identified, accurately described, and intelligently named during the New York survey, and appropriately bearing for all time typical names originally belonging to mountains, rivers, lakes or cities of the Empire State.

For one of the accompanying photographs of professor Hall we are indebted to the courtesy of the Scientific American and the other, taken by my son, Dr. E. O. Hovey, at Uralskaia, Government of Perm, August 21st, 1897, is probably the last ever taken of him. The signature, is from one of his latest letters, dated May 25th, 1898.

The writer is aware that he has by no means exhausted his theme; nor did he undertake to do more than what was editorially suggested, namely, to "give a sketch of the life and work of James Hall." How impossible to compress within the limits of a magazine article, the traits, characteristics, successes and occasional failures, of one whose opportunities for research were such as perhaps no other ever enjoyed, whose longevity and vitality were most remarkable, whose assistants numbered some of the most highly trained and ambitious geologists and paleontologists this country has yet produced, and whose resources, unwearied energy, flexible adaptability, and executive wisdom were rarely rivalled and never perhaps excelled.

The appendices, giving his bibliography, and the list of his titular honors, will afford the reader a bird's eye view of what

was accomplished by this wonderful worker, and what was thought of him by the grateful nations and institutions of the world.

James Hall's Titles and Memberships.

(The following list, furnished me by Prof. John M. Clarke, is probably the only complete one that has been made up. H. C. H.)

James Hall: B. N. S. (Troy, 1832); A. M. (Troy, 1833), (Union, 1842); M. D. (Univ. Maryland, 1846); LL. D. (Hamilton, 1863), (McGill, 1884), (Harvard, 1886).

State Geologist of New York (1837, 1893), and Palæontologist of New York (1843, 1893); State Geologist of Iowa (1854); Commissioner of Geological Survey of Wisconsin, (1857).

Mem. Soc. Mineral. de St. Petersb. (1837); Cor. Memb. Amer. Philos. Soc. (1843); Memb. Soc. Geol. de France (1845); For. Memb. Geol. Soc. London (1848); Fell. Amer. Acad. Arts and Sci. (1848); Memb. Albany Inst. (1851); Hon. Memb. N. Y. Lyc. Nat. Hist. (1852); Memb. K. K. Geol. Reichsanst. Vienna (1855); Mitgl. d. Gesellsch. für Nat. u. Heilk. Dresden (1855); Hon. Memb. Nat. Hist. Soc., Montreal (1856); Pres. Amer. Assoc. Adv. Sci. (1856); Hon. Memb. Iowa State Hist. Soc. (1857); Wollaston medalist (1858); Memb. Soc. Cæs. Nat. Curios. Moscow (1858); Cor. Memb. Chicago Acad. Sci. (1858); Cor. Memb. Maryland Hist. Soc. (1858); Cor. Memb. Naturahist. Gesellsch. Basle (1860); Cor. Memb. Naturhist. Gesellsch. Nuremburg (1860); Hon. Memb. Portland Soc. Nat. Hist. (1862); Hon. Memb. Buffalo Soc. Nat. Sci., (1863); Chart. Memb. Nat. Acad. Sci. (1863); Memb. Conchol. Sect. Acad. Nat. Sci., Phila. (1867); Memb. Brit. Assoc. Adv. Sci. (1872); Cor. Memb. Soc. Roy. des Sciences, Liege (1873); Hon. Memb. Minn. Acad. Nat. Sci. (1873); Pres. Albany Inst. (1878); Vice-Pres. Inter. Geol. Congress, Paris (1878); Memb. Acad. Cæsar. Leopold. Carol. German. Nat. Curios. (1879); Vice-Pres. Inter. Geol. Congress, Bologna (1881); Recipient of the Ricord. di Benemerenza, (1881); Decoration, Order dei Santi Maurizio Lazzaro (1882); Cor. Memb. Roy. Acad. Valern. del Poggio (1883); Recipient Walker Quinq. Grand Prize, Bost. Soc. Nat. Hist. (1884); Cor. Memb. Inst. of France (1884); Vice-Pres. Inter. Geol. Congress, Berlin (1885); Memb. Königl. Gesellsch. der Wisssensch. Göttingen (1885); Hon. Memb. Nat. Hist. Soc. Montreal (1886); Hon. Memb. Austro-Hung. Geol. Soc. (1886); Memb. Roy. Acad. Belgium (1887); Hon. Memb. Belg. Soc. Geol. Palæontol. Hydrol., Brussels (1887); Hon. Memb. Essex Inst. (1887); Cor. Memb. Roy. Inst. Sci. Lett. and Arts, Venice (1889); Pres. Geol. Soc. Amer. (1889); Hon. Fell. Am. Assoc. Adv. Sci. (1890); Recipient of Hayden Medal, Acad. Nat. Sci., Phila. (1890); Meb. Acad. Reg. Lincei, Rome (1894); Vice-Pres. Soc. Geol., France (1896); Ancien President Honoraire, Inter. Geol. Congress, St. Petersburg, (1897).

The Published Works of James Hall.

(In the Thirty-sixth Annual Report of the N. Y. State Museum of Natural History, a list was published, prepared by Dr. David Murray, including all published works from 1836 to 1882. Supplementary lists were published in 1886 and 1888, which appeared in the Forty-second Annual Report. At my request, Prof. John M. Clarke, state paleontologist of New York, has kindly brought the list down to date. This is regarded as complete, with the possible exception of a few minor publications which Dr. Hall himself overlooked in giving the data for this catalogue.) (H. C. H.)

Part I. Books.

1. Geology of New York. Part IV, comprising the survey of the Fourth Geological District; pp. 682, maps and plates. Albany, 1843. 4to.

2. Fremont's Exploring Expedition: Appendix A. Geological formations; pp. 295-303. B. Organic Remains; pp. 304-310, 4 plates. Washington, 1845. 8vo.

3. Palæontology of New York. Vol. 1; pp. xxiii, 338; plates, 100. Albany, 1847. 4to.

4. Report on the Geology of the Lake Superior Land District. By J. W. Foster and J. D. Whitney:

Lower Silurian System. Chapter 9, pp. 140-151. Washington, 1851. 8vo.

Upper Silurian and Devonian Series. Ibid. Chapter 10, pp. 152-166.

Description of New and Rare species of Fossils from the Palæozoic Series. Ibid. Chapter 13, pp. 203-231.

Parallelism of the Palæozoic Deposits of Europe and America. Ibid. Chapter 18, pp. 285-318.

5. Stansbury's Expedition to the Great Salt Lake. Geology and Palæontology; pp. 401-414. Philadelphia, 1852. 8vo.

6. Palæontology of New York. Vol. II; pp. viii, 362; 104 plates. Albany, 1852. 4to.

7. United States and Mexican Boundary Survey (Emory). Geology and Palæontology of the Boundary; pp. 103, 140, 20 plates. Washington, 1857. 4to. Also published in American Journal of Science, 2d Ser. See vol. 24, pp. 72-86. New Haven, 1857.

8. Geological Survey of the State of Iowa. Vol. I, part 1. Hall and Whitney. General Geology. Chapter II, pp. 35-44. Geology of Iowa. General Reconnoissance. Chapter III, pp. 45—46. Part II. Palæontology of Iowa. Chapter VIII, pp. 473—724, 29 plates. Albany, 1858. 4to.

9. Contributions to the Palæontology of Iowa, being descriptions of new species of Crinoidea and other fossils (supplement to vol. I, part II, of the Geological Report of Iowa); pp. 1—92, 3 plates. Albany, 1859.

10. Iowa Geological Survey. Supplement to vol. I, part II; pp. 1—4. 1859. 4to.

11. Palæontology of New York. Vol. III, part I, text; pp. xiii. 522. Albany, 1859. 4to.

12. Supplement to Vol. 1, published in Palæontology of New York. Vol. III, pp. 495—529. Albany, 1859. 4to.

13. Palæontology of New York. Vol. III, pt. II, plates. 141 plates and explanations. Albany, 1861. 4to.

14. Report on the Geological Survey of the State of Wisconsin. Vol. I, James Hall and J. D. Whitney. Madison, 1862. 8vo.

Chapter I, Physical Geography and General Geology, pp 1—72.

Chapter IX, Palæontology of Wisconsin; pp. 425—448.

15. Geological Survey of Canada, Figures and Descriptions of Canadian Organic Remains. Decade II. Graptolites of the Quebec Group; 151 pages, 23 plates. Montreal, 1865. 8vo and 4to.

16. Palæontology of New York. Vol. IV, pt. I, pp. xi. 428, 69 plates. Albany, 1867. 4to.

17. Geological Survey of the State of Wisconsin, 1859—1863. Palæontology; part III. Organic Remains of the Niagara Group and Associated Limestones; pp. 1—94, 18 plates. Albany, 1871. 4to.

(Same as published in 1864 in advance for 18th Report and 20th Report, New York State Museum of Natural History, 1867, under title of "Account of Some New or Little Known Species of Fossils from Rocks of the Age of the Niagara Group," also in revised edition of same in 1870.)

18. Geological Survey of Ohio. Vol. II. Geology and Palæontology; part II, Palæontology. Columbus, 1875. 8vo.

Descriptions of Silurian Fossils, James Hall and R. P. Whitfield. Ibid., pp. 65—161.

19. Descriptions of Crinoidea from the Waverly Group, James Hall and R. P. Whitfield. Ibid., pp. 162—179.

20. Illustrations of Devonian Fossils; 7 pages, 133 plates, with interleaved descriptions. Albany, 1876. 4to.

21. United States Geological Exploration of the Fortieth Parallel. Clarence King. Vol. IV. Ornithology and Palæontology; part II. Palæontology, James Hall and R. P. Whitfield; pages 199—302, 7 plates. Washington, 1877. 4to.

22. Palæontology of New York. Vol. V, pt. II, text pp. xv, 492. plates 120. Albany, 1879. Oto.

[Sen. Doc. No. 53.]

23. Palæontology of New York, vol. V, Part 1. Lamellibranchiata I, text and plates, pp. xviii, 268; plates, 45. Albany, 1884. 4to.

24. Palæontology of New York, vol. V, Part 1. Lamellibranchiata II, text and plates, pp. lxiv. 269—562; plates, 52. Albany, 1885. 4to.

25. Palæontology of New York, vol. V, Part 1. Lamellibranchiata. plates and explanations, pp. 20; plates 78. Albany, 1883. 4to.

26. Palæontology of New York, vol. VI; Corals and Bryozoa. By

James Hall, assisted by George B. Simpson, pp. xxvi, 298, plates 66. Albany, 1887.

27. Palæontology of New York, vol. VII. pp. lxiv. 236; plates 46. By James Hall assisted by John M. Clarke. With supplement to Vol. V, part II, pp. 42, plates 114—129. Albany, 1888. 4to.

28. James Hall, assisted by J. M. Clarke. Palæontology of New York, vol. VII. Text and Plates. Containing Descriptions of the Trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. pp. i—lxiii, 1—236, pls. 1—xxxvi (=49). 1888.

29. James Hall. Palæontology of New York, vol. V, part II. Supplement. Containing Descriptions and Illustrations of Pteropoda and Cephalopoda and Annelida. pp. 1—42, pls. cxiv—cxxxix. 1888.

30. James Hall. Description of New Species of Fenestellidæ of the Lower Helderberg group, with Explanations of Plates illustrating species of the Hamilton Group, described in the Report of the State Geologist for 1886. (Ann. Rept. State Geologist for 1887, pp. 391—392 (41st Mus. Rept.) pls. viii—xv.)

31. James Hall. Crustacean Tracks in the Potsdam Sandstone. (42d Ann. Rept. N. Y. State Mus., pp. 25—34, plate.) 1889.

32. James Hall, assisted by J. M. Clarke. (On the genus Orbiculoidea.) (Published in adv. Pal. N. Y., vol. 8, pt. 1, pp. 120—160, pls. ive—ivf.) 1889.

33. James Hall. Preliminary Notice of Newberria, a New Genus of Brachiopoda with Remarks on its Relations to Rensselæria and Amphigenia. (Tenth Ann. Rept. N.Y. State Geol. pp. 91—99. pls. v and vi. 1891.)

34. James Hall, assisted by J. M. Clarke. Palæontology of New York, vol. VIII. An introduction to the study of the genera of the Palæozoic Brachiopoda, part 1, pp. i—xvi, 1—367, pls. 1, 2, i—xx (=44.) 1892.

35. James Hall, assisted by J. M. Clarke. Palæontology of New York, vol. VIII, part 2, fascicle 1, pp. 1—176. 1893.

36. James Hall, assisted by J. M. Clarke. Palæontology of New York, vol. VIII, part 2, fascicle 2, pp. 177—317. 1893.

37. James Hall, assisted by J. M. Clarke. An Introduction to the study of the Brachiopoda, intended as a Handbook for the use of Students. Part 1. (11th Ann. Rept. N. Y. State Geologist, pp. 128—300, plates 1—22, 1892.)

38. James Hall, assisted by J. M. Clarke. An introduction to the study of the Brachiopoda, intended as a Handbook for the use of Students. Part 2. (13th Ann. Rept. N. Y. State Geologist, pp. 749—943, pls. 23—54. 1894.)

39. James Hall, assisted by J. M. Clarke. Palæontology of New York, vol. VIII. An Introduction to the Study of the Palæozoic Brachiopoda. Part 2. pp. i—xvi, 1—394, pls. xxi—lxxxiv. 1894.

40. James Hall, assisted by J. M. Clarke. The New Species of

Brachiopoda described in Palæontology of New York, vol. VIII. parts 1 and 2. (14th Ann. Rept. State Geol. pp. 323—402, pls. 1—14. 1895.)

41. James Hall, in collaboration with J. M. Clarke. A Memoir on the Palæozoic Reticulate Sponges constituting the Family Dictyospongidæ. Part 1. Fifteenth Ann. Rept. State Geol. vol. 2, pp. 739—984, pls: 1—xlvii. (In press.)

42. James Hall, in collaboration with J. M. Clarke. A Memoir on the Palæozoic Reticulate Sponges constituting the family Dictyospongidæ. Part 2. Sixteenth Ann. Rept. N. Y. State Geol., pp. 341, pls. xlviii—lxx. (In press.)

Part II.

Scientific Papers Published in Reports, Transactions of Societies, Journals, Magazines, Etc.

N. B.—The title or an abstract only was given of papers in the list marked with asterisk (*), as full notes were not furnished for publication.

1. Catalogue of Plants, Growing without Cultivation, in the Vicinity of Troy. John Wright and James Hall, 42 pages. Troy, 1836. 8vo.

2. Descriptions of two species of Trilobites, belonging to the genus Paradoxides. American Journal of Science and Arts. Vol. XXXIII, pp. 139—143. New Haven, 1837. 8vo.

3. Second Annual Report of the Fourth Geological District of New York. Assembly Doc. 200, pp. 287—373. Albany, 1838. 8vo.

4. Third Annual Report of the Fourth Geological District of the State of New York. Assembly Doc. 275, pp. 287—339. Albany, 1839. 8vo.

5. Fourth Annual Report of the Survey of the Fourth Geological District. Assembly Doc. 50, pp. 389—456. Albany, 1840. 8vo.

6. Fifth Annual Report of the Fourth Geological District, Assembly Doc. 150, pp. 149—180. Albany, 1841. 8vo.

7. Notes explanatory of a section from Cleveland, Ohio to the Mississippi river, in a southwest direction, with remarks upon the Identity of the Western Formations with those of New York. Transactions of the Association of American Geologists and Naturalists; pp. 267—293. Boston, 1842. 8vo.

8. Remarks upon Casts of Mud Furrows, Wave Lines, and other Markings upon Rocks of the New York System. Ibid., pp. 422—432.

9. Niagara Falls. Their physical changes and the Geology and Topography of the surrounding country. Boston Journal of Natural History. Vol. IV, pp. 106—134. Boston, 1842. 8vo.

10. Notes upon the Geology of the Western States. American Journal of Science and Arts. Vol. XLII, pp. 51—62. New Haven, 1842. 8vo.

11. *Geographical Distribution of Fossils of the Palæozoic Strata of the United States. Proc. Am. Assoc. Geol. and Naturalists published in American Journal of Science and Arts. Vol. 45, pp. 157—160. New Haven, 1843. 8vo.

12. *Ripple Marks and Casts of Furrows. Ibid. Vol. 45, pp. 148—149. New Haven, 1843. 8vo.

13. *Sections at Portage. Ibid. Vol. 45, pp. 329—330. New Haven, 1843. 8vo.

14. Address before the Society of Natural History of the Auburn Theological Seminary, 1843; pp. 1—20. Auburn, 1844. 8vo.

15. *Geographical Distribution of Fossils. American Journal of Science, vol. 47, pp. 117—118. New Haven, 1844. 8vo.

16. Description of Some Microscopic Shells from the Decomposing Marl Slate of Cincinnati. Ibid. Vol. 48, pp. 292—295. New Haven. 1845. 8vo.

17. Notice of the Geological Position of the Cranium of the Castoroides Ohioensis. Boston Journal of Natural History, vol. V, pp. 385—391. Boston, 1846. 8vo.

18. *On the supposed impression in Shale of the soft parts of an Orthoceras. Quar. Journal, Geological Society, London, vol. V, pp. 107—111. London, 1848. 8vo.

19. On the Parallelism of the Palæozoic Deposits of North America, with those of Europe; followed by a table of the species of fossils common to the two continents, with indication of the positions in which they occur, and terminated by a critical examination of each of these species; by Ed. de Verneuil (translated and condensed from the Bulletin of the Geological Society of France, 2d Ser., vol. IV). Am. Jour. Science and Arts, 2d Ser., vol. V, pp. 176—183, 359—370. New Haven, 1848. 8vo. Ibid. 2d Ser., vol. VII, pp. 45—51, 218—231. New Haven, 1849. 8vo.

20. Remarks on the Observations of S. S. Haldeman "on the supposed identity of Atops trilineatus with Triarthrus Beckii." Am. Jour. Sci. and Arts, 2d Ser. vol. V, pp. 322—327. New Haven, 1848. 8vo.

21. Catalogue of Specimens in the Geological Department of the Geological Survey of New York. First Ann. Report on the State Cab. of Nat. Hist., 39 pages. Albany, 1848. 8vo.

22. Catalogue of specimens in the Palæontological Department of the Geological Survey of New York. Ibid., 15 pages.

23. *Upon some of the Results of the Paleontological Investigations in the State of New York. Am. Jour. Sci., 2d. Ser., vol. V, pp. 243—249. New Haven, 1848. 8vo.

24. List of Minerals, Geological Specimens and Fossils, added to the collections, 1847, 1848. Second Ann. Report of State Cab. of Nat. Hist.; 4 pages. Albany, 1849. 8vo.

25. On the Trails and Tracks in the Sandstones of the Clinton Group of New York; their probable origin, etc.; and a comparison of some of them with Nereites and Myrianites. Proc. Am. Assoc. Ad. Sci.,

2d meeting (Cambridge), 1849, pp. 256—260. Boston, 1850. 8vo.

26. On the Brachiopoda of the Silurian Period; particularly the Leptænidæ. Ibid., pp. 347—350.

27. On Graptolites, their Duration in Geological Periods, and their Value in the Identification of Strata. Ibid., pp. 351—352.

28. Description of New Species of Fossils, and Observations upon some other Species previously not well known, from the Trenton Limestone. Third Ann. Report State Cab. Nat. Hist., pp. 167—175, 5 plates. Albany, 1850. 8vo.

29. *Remarks on the Geology of Mackinac, Drummond and St. Joseph's Islands and the Northern Shores of Lake Michigan. Proc. Am. Assoc. Ad. Sci., 4th meeting (New Haven), 1850, p. 354. Washington, 1851. 8vo.

30. *Report on the Invertebrate Fossils exhibited to the Association. Proc. Am. Assoc. Ad. Sci., 5th meeting (Cincinnati), 1851, p. 180. Washington, 1851. 8vo.

31. *Parallelism of the Palæozoic Rocks of New York, with those of the Western States, and of all those with the Palæozoic Strata of Europe. Ibid., p. 59.

32. *On the Silurian Rocks of the Lake Superior Land District. Ibid., pp. 64—66.

33. *Catalogue of specimens of the Rocks and Fossils in the Gray Sandstone, Medina Sandstone, Clinton Group, Niagara Group, Onondaga Salt Group, and a part of the Waterline Group. 4th An. Rep. N. Y. St. Cab. Nat. Hist., pp. 119—146. Albany, 1851. 8vo.

34. On Drummond's Island. Proc. Am. Acad. Arts and Sciences, vol. II, pp. 253, 254 Boston, 1852.

35. *Comparison of the Geological Features of Tennessee with those of the State of New York. Proc. Am. Assoc. Ad. Sci., 6th meeting (Albany), 1851, pp. 256—259. Washington, 1852.

36. *Remarks upon the Fossil Corals of the Genus Favosites, and allied Fossil Genera Favistella, Astrocerium and others. Ibid., p. 306.

37. *On the Palæozoic Genera Trematopora, Cellepora, etc. Ibid., p. 306.

38. *Tracks, Trails, etc., in the Shales and Sandstones of the Clinton Group from Green Bay, with remarks on the thinning out and reappearing of this portion of the Clinton Group. Ibid., p. 306.

39. *Remarks on the Trilobite of the Potsdam Sandstone, named by Dr. Owen, Dikellocephalus, and its Relations to Asaphus and Ogygia. Ibid., p. 301.

40. *Remarks upon the Fossils of the Potsdam Sandstone. Ibid., p. 304.

41. Notice of a Geological Map of the United States and the British Provinces of North America, with Explanatory Text, Geological Sections and Plates of the Fossils which characterize the formations, by J. Marcou. Am. Jour. Sci., 2d Ser., vol. 17, pp. 199—206. New Haven, 1854. 8vo.

42. Rapport sur la Partie Geologique de l'Exposition de New York. C. Lyell and J. Hall. Traduit par M. A. Langel. Annales des Mines, vol. VI, pp. 1—85. Paris, 1854. 8vo.

43. Report on Coal Lands in Kentucky, for the Kentucky Mining and Manufacturing Company. B. Silliman and J. Hall, pp. 16. New York, 1855. 8vo.

44. *Observations upon the Geology of the Mauvaises Terres, Nebraska, with Notices of the Geographical and Geological Range of some of the Fossils of that Region. Proc. Am. Assoc. Ad. Sci., 8th meeting, Washington, 1854, p. 290. Cambridge, 1855. 8vo.

45. *Remarks upon a Collection of Cretaceous Fossils from Nebraska, and the Absence of Species known in the Southern Extension of the Same Formation. Ibid., p. 290.

46. *Remarks upon the Results of Extensive and Continued Collections of Fossil Species from a Portion of the Silurian Rocks of New York, showing the Number of Species and Individuals of each Species Obtained from a Limited Locality during a Period of Ten Years. Ibid., p. 290.

47. *On the Reproduction of Similar Types or Representative Species in Successive Geological Formations. Illustrated by a Collection of Species of the Brachiopoda from the Niagara and Lower Helderberg Groups of the Palæozoic Rocks of the United States. Ibid., p. 290.

48. *Red Sandstone of the Connecticut River Valley, and the Proofs of its Oölitic or Liassic Age. Ibid., p. 290.

49. *Remarks upon the Geological Formation of the country along the Line of the [Mexican] Boundary Survey, based upon the Examinations of Dr. Parry, made under the Order of Major [W. H.] Emory. Ibid., p. 291.

50. *The Silurian and Devonian Systems, and the Nature of the Evidence for Drawing a Line of Separation between the two Systems in the United States. Ibid., p. 291.

51. *On the Western Limits of the Cretaceous Formation on the Northern Continent of America, as Evidenced by the Various Collections that have been made by Exploring Expeditions under the Direction of the Government of the United States. Ibid., p. 291.

52. *Contributions to our Knowledge of the Geology of Nebraska and the Mauvaises Terres. Proc. Am. Assoc. Ad. Sci., 9th meeting, Providence, 1855, p. 277. Cambridge, 1856. 8vo.

53. *Notes upon the Genus Graptolithus. Ibid., p. 277.

54. *On the Development of the Septa in the Genus Baculites, from the extreme Young to the Adult State. Ibid., p. 277.

55. Descriptions of New Species of Fossils from the Cretaceous Formations of Nebraska, with Observations upon Baculites ovatus and B. compressus; and the Progressive Development of the Septa in Baculites, Ammonites and Scaphites. J. Hall and F. B. Meek. Memoirs of the American Academy of Arts and Sciences, vol. V, new series, pp. 379—411, 8 plates. Cambridge, 1856. 4to.

56. On the Genus Tellinomya, and Allied Genera. The Canad. Nat. and Geol., vol. 1, pp. 390—395. Montreal, 1856. 8vo.

57. Observations on the Genus Archimedes, or Fenestella, with Descriptions of Species, etc. Proc. Am. Assoc. Ad. Sci., 10th meet ing, Albany, 1856, pp. 176—180. Cambridge, 1857. 8vo.

58. On the Carboniferous Limestones of the Mississippi Valley. Ibid., pp. 51—69.

59. Opening Address before the Am. Association. Ibid., pp. 230 —232.

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NOTES ON THE DRIFT OF NORTHWESTERN IOWA.*

By H. FOSTER BAIN, Des Moines, Iowa.

In northwestern Iowa and adjacent portions of South Dakota and Minnesota there is a large V-shaped area with the apex pointing north lying between the Dakota and the Des Moines lobes of the later ice sheet. The area is bounded to the east and to the west by the first or Altamont moraine, which has been thought to mark the maximum extension of what is now known as the Wisconsin drift sheet. This area is covered by an extra-morainic drift sheet and it is the age of this drift and its associated deposits which it is proposed to discuss in this paper.

This drift has been imperfectly known for some time and there are extant certain meager notes on it. In the reports of the Minnesota survey it has been described by Winchell and by Upham as shown in Murray and Nobles† and Pipestone and Rock counties.‡

The drift was considered by the Minnesota geologists to

*Read before the Iowa Academy of Science.

†Upham: Final Rept. vol. I, p. 250.

‡Winchell, N. H.: Ibid., p. 543-545.

belong to the earlier ice sheet and the loess-loam was believed to belong in age with this earlier drift rather than with the moraines.* The loess was mapped as approximately bounded by the 1500 feet contour; though with reservations. When later, finer discriminations came into vogue, Chamberlin considered both the Iowan and Kansan to be displayed in the region.† The Iowa survey has been disposed to refer the whole to the Iowan‡ though recognizing that the Kansan is present in the region.§

At its southern extremity the Des Moines lobe of the Wisconsin rests on the Kansan.‖ Along its eastern front as far south as Hardin county the drift immediately outside the moraine is Iowan.¶ The over-lap by which the Wisconsin is brought to rest on the Kansan is quite extensive and the relations between the Kansan and Wisconsin are characteristically displayed as far north as Carroll county. In the region northwest of that county the relations along the border are not always clear and the drift has been considered too young in appearance to be correlated with Kansan. So far no Illinoian drift has been recognized in the region. The previous references of the drift to Iowan seem now unadvisable as a result of the observations, yet unpublished, of professor Macbride in Humboldt and Dr. Beyer in Story counties. The drift must accordingly be Kansan, Illinoian or early Wisconsin. It may belong in part to any two of these or indeed all these may be present though the latter is considered improbable. In the course of the last field season certain exposures of apparently young drift in Carroll county have been proven to be Kansan and it has been found that many of the criteria which in southern Iowa and in Illinois allow the ready and secure recognition of that drift sheet, partially fail when applied to the region in question.

The Kansan drift, where typically displayed, exhibits a ma-

*See Winchell, Loc. cit., p. 545.

†See plate IV, Geikie's Ice Age (3rd Ed.) 1895.

‡Calvin: Iowa Geol. Surv., vol. VII, p. 20; Bain, Ibid, vol. VI, pp. 462-463, vol. VIII, pp. 341-351.

§Iowa Geol. Surv., vol. V, p. 279, et seq.

‖Rel. Wisconsin and Kansan Drift Sheets in Central Iowa; Iowa Geol. Surv., vol. VI, pp. 433-476.

¶Iowa Geol. Surv., vol. VII, pp. 174-176.

ture drainage system, a well developed erosion topography and a change of color from blue at the base to yellow in the upper portion. The exposures in southern Iowa usually show in addition a decrease in lime and an increase in rotted bowlders toward the surface with the almost invariable development of what is called the ferretto* and the occasional presence of a forest bed or series of water laid deposits between the drift and the loess. Of these phenomena the absence of lime and presence of ferretto are most widespread and most easily recognized. The drift is very largely made up of mechanically prepared material. The finer parts consist of broken and finely ground rock. Inasmuch as the glaciers passed over vast areas of limestone, a fresh drift normally carries large quantities of crushed limestone. This when touched by any of the common acids has the property of effervescing. When limestone is exposed to weathering agencies the soluble material is carried off and that which remains is unacted on by ordinary acids. When a fresh drift containing small bits of limestone is exposed for a long time to weathering agencies, the same process takes place. After a time all the soluble part of the limestone particles is carried away and the drift shows no reaction to the acid. It is thus possible normally to distinguish between an old, long exposed drift and a fresh one and in southern Iowa it has been found that before the loess was laid down the Kansan drift was so long exposed to the agencies of solution that there is no reaction to the acid at its upper surface and only a feeble reaction to depths of five to nine feet below. On the other hand the younger drift sheets with the rarest exceptions show an effervescence up to the very grass roots.

Practically all rocks carry a greater or less percentage of iron. The amount, while small, is usually the determining factor in the matter of color. As commonly found in the rocks iron exists in four forms: the carbonate ($FeCO_3$=Fe 48.27 per cent which effects various shades of blue; limonite (Fe_2O $3H_2O$=Fe 59.89 per cent) and the various earthy ochers which vary in shade from yellow to brown; hematite which (F_2O_3=Fe 70. per cent) in the pulverized form is red, and magnetite (Fe 3O =Fe 72.5 per cent) which is black.

*Proc. Iowa Acad. Sci., vol. V, p. 90.

Magnetite is rarely an important constituent of sedimentary though common in the igneous and metamorphic rocks. As will be seen from the chemical formulas the carbonate contains relatively the least oxygen, and of the three common forms the hematite contains the most, and limonite and the various earthy ochers occupy an intermediate position. If then a mass of rock whose color is determined by the iron content be subjected to oxidation the color will pass progressively from drab or blue through yellow and brown to red. The latter color is the indicating mark of a high stage of oxidation. Oxygen is one of the most active chemicals in the air and oxidation is one of the most widespread and prevalent processes to which rocks are subjected in weathering. In driftless areas, where the soil has been formed by the slow weathering away of the rocks red soils are common. In the driftless area of Iowa and adjacent states the hard blue limestone and dolomytes of the Palæozoic have been leached and oxidized till a sticky red clay called geest, alone remains. In many of the southern states beyond the limits of glacial action red soils of this genesis are common.

Where drift is exposed to atmospheric agencies the processes of weathering are closely akin to those which take place in the weathering of ordinary rocks. The chemical activities are relatively more intense as the material is already broken up and there is no need to wait for the slow processes of frost action to shatter the rock. The finely comminuted rock flour is at once attacked by chemical agents and decalcification, oxidation and ferrugination at once set in. Old drifts accordingly soon become highly oxidized. The iron assumes a deep brown to red color. This color is less and less intense from the surface downward. The iron aggregates and to a certain extent sometimes cements the soil. This dark, iron-stained and highly oxidized band at the surface of the loess is what is called the ferretto. In southern Iowa it is widespread below the loess and at the surface of the drift and is interpreted as indicating a considerable period of weathering between the deposition of the two beds.

The oxidation which produces the ferretto leads also to the breaking down of the bowlders at the old drift surface. It is a very usual thing to find the granites and other crystal-

line rocks which at some depth in the drift are fresh and hard, thoroughly disintegrated at the contact between the Kansan and the loess. Often they may be crushed between the fingers. It is not very unusual to find rotted bowlders in any portion of the older drifts as would be suspected from the fact that the older drift sheets had much rotted material to work with. But it is frequently possible to prove that the disintegration of the bowlders at the surface of the drift took place after they had been shaped by the ice and furthermore, the number of rotted bowlders usually increases with the nearness to the surface. Accordingly this phenomenon accords with the decalcification and the development of ferretto in indicating a period of considerable exposure to weathering agencies.

The extra-morainic drift of Carroll county occurs in two facies; one, the normal Kansan, showing ferretto, leaching, rotted bowlders, etc., and the other an abnormal type in which these phenomena are lacking. The outcrops of these two phases are inextricably mixed. Each occurs in areas wholly surrounded by ordinary, simple erosion. The field relations indicate clearly that they are but different phases of the one drift. The abnormal phase of the drift shows no trace of ferretto and is wholly unleached. It effervesces up to the loess contact when tested with acid. It contains more rotted bowlders but they are not usually more abundant at the top than the bottom. In many particulars it is indistinguishable from a young drift and yet the most careful search in the field has so far failed to reveal any dividing line either vertical or horizontal between it and the normal Kansan. If there were two drift sheets in the region, the one fresh and unleached and the other old and ferretto-covered the younger drift could hardly have the patchy geographical distribution necessitated by the facts in the present case except upon the hypothesis of its being thin and much eroded. Single exposures of more than thirty feet are, however, known and there is no evidence whatever of more than one period of erosion between the drift and the loess. No cases of superposition have been detected nor are there accounts of forest beds, buried loess sheets or other evidences of an interglacial period. Both sorts of drift have exactly the same relations to the loess which in turn shows no evidence of being anything except a homogeneous

deposit. Except that Wheatland township seems less eroded by its position far from large streams, there is no apparent evidence in the topography of difference in the age of the various parts of the region. Accordingly the two sorts of drift are believed to represent but differing phases of the Kansan. The unleached drift resembles closely the Kansan usually found five to ten feet below the base of the ferretto. It is as if a portion of the Kansan had been in places eroded: and that, in short, is believed to be the correct explanation of the phenomena.

It is obvious that the presence of the lime in the drift depends upon its original abundance and the degree to which it has been carried away. The former is wholly independent of the time the drift has been exposed and the latter may or may not vary with the time but in the absence of specific evidence to the contrary may be fairly assumed to be dependent on that factor. All the drift sheets of Iowa carry when unaltered, enough lime to make the acid test a valuable one. The presence or absence of lime then in the upper portion may, unless good evidence of its exceptional nature be offered, be considered to indicate the amount of exposure which the drift has suffered. The amount of lime leached from a calcareous drift will depend upon the strength of the solvent and the amount passing through the drift in a given time. It will also depend upon the direction which the percolating waters take. In an arid region the excessive evaporation may locally cause the flow of ground water to be upward and lead to the deposition of soluble salts in the upper portion of the soil. This factor can, however, hardly be important in the present case. There is no reason to believe that water soaking into the ground in one part of Iowa varies greatly in solvent power as compared with that in any other part when considerable districts are considered. There are of course wide differences in detailed areas, but in general the rain water, which is the original source of the underground circulation, seems as likely to become charged with humus and other acids at one point as another. It is true, however, that the amount of water entering the ground varies widely. There are considerable differences in the rain fall in different parts of the state, the variation in 1897 being from 18.43 inches to

36.18.* In the northwest it varies from 15 to 20 inches and in the southeast from 20 to 25 with areas running from 25 to 30. The run-off also varies widely. There are no data relative to Iowa streams but it is well known that run-off is proportional to the character of the surface, the slope, and the time distribution of the rainfall. It is greater on a non-absorbent surface, on greater slopes, and when the rain fall is bunched. In the present case the surface of the Kansan drift seems not to vary in any systematic way with relation to its capacity to absorb water. The rainfall in Carroll county is probably as evenly distributed as in other parts of the state. There are, however, considerable differences in slope. It is to be remembered that the region represents the high upland between the Mississippi and the Missouri. The railway grades across the county are heavy and the stream grades are even greater. The drainage consists of the headwater portions of the streams only, and the water reaches them by running over the steep surface slopes rather than through the ground. Springs, in the southwestern part of the county, are almost unknown and seepage is rare. The whole of the evidence indicates that the water passes over rather than through the drift and hence that solution is relatively slight. This seems to be one of the important factors in the failure of the leaching test.

Where the grades are high and the amount of surface water notably in excess it must be obvious that erosion will be very active. This will be true of the slower and less easily noticed surface erosion of the inter-stream areas as well as the direct corrasion of the streams. It has already been suggested that stream action in the region is intense. It is also true that the erosion of the general surface is much greater than on the low wide divides further south. The relations of the loess to the river valleys indicate that the latter occupied approximately the same position in the interval between the Kansan and the loess that they do now, so that erosion was probably at least as active then as now. This is probably the main explanation of the absence of the ferretto and leached drift in the region under discussion. Aside from the fact that there may have been less leaching here than in lower lying

*Rept. Iowa Weather and Crop Service, 1897.

regions, the active erosion by which the stained and leached material has been carried away as fast as formed, is probably the main factor in the explanation.

In very many instances where the more weathered portion of the Kansan is absent the field evidence shows that its absence is probably due to local intensity of erosion. The fact that erosion over a general surface presents the widest variation in intensity and effects from point to point, is not perhaps always appreciated as thoroughly as it should be. A difference of five to ten feet in the amount of erosion on neighboring swells and divides is not unusual but where the uppermost stratum happens to be so strongly marked as is the ferretto zone the effect of this difference becomes very striking. On high land much cut up by streams, erosion is very active and it seems reasonable to believe that these minor differences from point to point would be correspondingly magnified. These very conditions prevail now over most of the territory in question and the stream history of the region, so far as it can be read, indicates that conditions were not greatly different before the loess was laid down.

The high divide in Madison and Union counties between Clanton creek and Grand river shows a corresponding local variation in the amount of erosion. At numerous points the yellow unleached drift of the Kansan is exposed at the surface in the heart of a region where leached drift and ferretto are widespread. In this case the erosion, since the exposures are loess-covered, seems to be recent. In the case of the Carroll county outcrops the erosion would be mainly pre-loessial.

No attempt can be made here to fix the age of the extramorainic and fresh-looking drift found in the counties to the north. The work of the present field season has shown that the reference of this drift to the Iowan is probably wrong. The work in Carroll county has shown that there is danger of confusing certain phases of the Kansan with the later drifts. It is possible that a limited extent of northwestern part of Carroll county is covered by the later drift. The exposures are few and such as are found are of the equivocal type. There are, however, no marked border phenomena such as elsewhere denote the limits of a drift sheet and the possibility of a later extra-morainic drift within the limits of the county

is believed to be remote. Until, however, the counties to the north are studied in more detail than has so far been possible, the absence of such later drift can not be positively affirmed. It may be said, however, that so far no extra-morainic drift is known as far north as Carroll county which is not known to be Kansan or might not readily be assigned to that formation.

[Contributions to the Mineralogy of Minnesota. V.]

COMMON ZEOLITES OF THE MINNESOTA SHORE OF LAKE SUPERIOR.

By N. H. WINCHELL, Minneapolis, Minn.

Stilbite. This zeolite is sometimes confounded in the field with heulandite. It is easily cleavable parallel to 010 and presents a shining or nacreous surface which often gives an iridescent reflection. Its color is white, when pure, but its most frequent color includes some shade of red, or orange red, due to the presence of more or less hematite intercalated in the cleavages and other openings. The optic plane is parallel with the cleavage (010), and hence a cleavage piece will show the emergence of n_m, a character which at once distinguishes it from heulandite.

Localities. Occurs at Splitrock point; Beaver bay; Little Marais; at three miles east of the mouth of Poplar river, where it affords large cleavable plates so twinned as to form more or less radiated and fan-shaped surfaces; mouth of False Poplar river; also near the mouth of Temperance river. Stilbite is frequently seen in company with heulandite.

Heulandite. Is usually red, frequently forms a coating in joint-planes in the basic rocks. Its cleavages show an axis of elasticity (n_g) in the acute angle of the optic plane. In the field its simpler cleavage and plates (i. e. untwinned) afford the best means of distinguishing this mineral from stilbite which is usually so twinned as to present its edges in diverse and multiple directions in the same mass. Heulandite is also more liable to show a cherry red stain of hematite. Under the microscope a single small cleavage fragment at once distinguishes it from stilbite, since in place of n_m it shows the bisectrix n_g.

Localities. It has been noted at the following points, but occurs in many others: east of Pork bay, in veins; at northeast corner section 28, 59-4w; two miles west of Little Marais.

Laumontite. This is the most abundant of the zeolites of Minnesota. It is found not only in nearly every scoriaceous trap-flow from Lester river eastward as far as to Grand Portage bay, but is abundant also in the soft red conglomerates which consist very largely of the debris of the basic eruptives. It occurs in small nests, filling cavities sometimes two inches in diameter, and in amygdaloidal vesicules. Its fibers radiate from points and are of a red or flesh red color but nearly white when fresh, but easily crumble away and disappear. They have extinction at 25°-30° from parallelism. The acute bisectrix is n_p but does not appear in cleavage surfaces. These present n_m, the easy cleavage being parallel to 010 which contains the optic plane. The elongation of the fibers is usually positive.

Localities. Some of the most important localities are: southeast ¼, section 34, township 51-13, east of Lester river in an amygdaloidal diabase, where may be seen an unusual disturbance of the strata, dipping in opposite directions, consisting of an acid scoria; mouth of Knife river and eastward to Agate bay; Little Marais, six miles east of Temperance river; three miles east of the mouth of Poplar river; at the beach east of Grand Marais. Laumontite is usually accompanied by calcite.

Mesotype. This mineral has been found in Minnesota in but one locality. With positive elongation and quadrangular sections, the axis n_g perpendicular to the base, the axial plane stands so as to subdivide the angle between the faces 110 and 1̄10. By micro-chemical test this mineral gave evidence of containing only soda.

Localities. Beaver Bay in veins in the gabbro (anorthosyte) masses at the west side of the bay.

A DEEP PRE-GLACIAL CHANNEL IN WESTERN OHIO AND EASTERN INDIANA.

By J. A. Bownocker, Columbus, Ohio.

(Plate VI.)

The counties in which this study was made include Shelby, Auglaize and Mercer in Ohio; and Adams, Jay and Blackford in Indiana. The territory lies north of the middle of the junction of the two states.

The topography is either flat or rolling. The latter character is due mainly to morainic deposits which extend across the territory in a general east and west direction. The diversity is further increased by the valleys of three streams which now drain the country.

The mantle of drift which covers the region varies in thickness from place to place. Starting in the southeast corner of Shelby county, Ohio, drift 180 feet deep is found without reaching bed rock. North of the Miami river in the same county a thickness of 173 feet is recorded without reaching rock. In the northwestern part of this county the drift becomes thinner, the rock lying one hundred feet or less below the surface. In the western part of Auglaize county the decrease in depth continues, the figures ranging from twenty-five to one hundred feet. Crossing into Mercer county depths of from forty-two to sixty feet are met in the territory lying north and south of the Grand reservoir. In the northwest part of the county, along St. Marys river, the rock is found at the surface. To the south, along the state line, the drift grows deeper, attaining a maximum depth of one hundred feet, but at two or more localities along the Wabash river the rock is again found at the surface.

Across the state line in Indiana the depths remain about the same as in the adjacent territory in Ohio. Along the Wabash river in Adams county the rock is found at the surface. West of the town Geneva depths ranging from twenty to eighty feet are reported. To the south in Jay county the drift is eighty feet deep at Bryant, while in the western part near Pennville it is only forty feet deep. Across the line in Blackford county the depth again increases, and figures ranging from eighty to one hundred and fifty feet are reported.

The present drainage of the region is through three rivers

one of which empties into lake Erie and the other two into the Ohio river. The rivers are the St. Marys, which, flowing to the west and north, unites with the St. Joseph to form the Maumee, the Great Miami which flows to the southwest, and the Wabash which, first pursuing a northwest course, turns to the southwest and empties into the Ohio. The Wabash and St. Marys rise in the territory under consideration, while the Miami rises in an adjoining county. Considerable of the locality under consideration is really a watershed separating the three named rivers. Situated near the middle of the territory is the Grand reservoir which covers about 17,000 acres, and is said to be the largest artificial body of water in the world.

The rock floor on which the drift lies is everywhere the Niagara and Lower Helderberg limestones. It was on the pre-glacial soil which covered these rocks, and in channels cut in these limestones that the pre-glacial streams flowed. When the great ice sheet advanced over this region it completely filled the valleys which it found, and deposited the mantle of drift. When the glacier receded it disclosed a new topography; the old valleys were deeply buried, and a low watershed was formed across the territory. Consequently a new drainage system developed, and this, as will be shown, is radically different from the pre-glacial one.

The course of the old drainage line has been disclosed by the driller for oil and gas. To him we are indebted for the following facts: At Anna, Shelby county, Ohio, 514 feet of drift were passed through. Within a mile east or west of this place the drift does not probably exceed 150 feet in depth. At Anna the old stream had cut entirely through the Niagara and Clinton limestones and into the Medina or Hudson shales. Running northwest to the Auglaize county line successive wells showed depths of drift of 320, 400, 440, and 440 feet, while the drift outside of, but near the channel nowhere exceeded 140 feet. Passing into Auglaize county and running toward the Grand reservoir successive wells showed depths of drift of 190, 380, 370, 370, 370, 370, and 370 feet. The shallowness of the first well above given is probably due to the well's having been put down near the margin of the channel. The depth in this locality outside of the channel ranges from

sixty feet near the Shelby county lines to twenty-five feet just east of the city, St. Marys. The five wells, sunk in as many miles, and all showing the same depth, suggest that this is the normal depth of the channel.

St. Marys at the canal is 814 feet above the sea level. The country to the southeast along the channel is quite level, and hence varies little in altitude from St. Marys. Taking 370 feet as the normal depth of the channel, it follows that the bed of the channel is 494 feet above sea level. The surface of lake Erie is 573 feet above tide; hence the channel is seventy-nine feet below the surface of lake Erie. Possibly the normal depth of the channel may be greater than 370 feet, and if so the depth of the channel below the surface of the lake is greater than the figure above given.

Continuing west from St. Marys the channel passes directly through Grand reservoir, but a little distance north of the middle line. Numerous walls here show depths ranging from 360 feet to 380 feet, while along the shores the drift varies from forty-five to one hundred feet. Near the west end of the reservoir the channel turns abruptly to the north, and between this point and Rockford depths of 400, 340, 300, 400, 400, 225, and 350 feet were found in successive wells. The deepest wells in this territory show that the old river had cut entirely through the limestones and was eroding the shales below. The drift on each side of the channel between the reservoir and Rockford is shallow, varying from sixty to eighty feet. Running due west from Rockford the channel can be followed, though the oil men have not invaded this territory. Water wells show depths of drift of 100 feet without reaching rock, while north and south of this line depths are notably smaller.

Passing into Adams county, Indiana, the same conditions prevail. Water wells show depths of 150 feet without reaching the rock, while north or south of this line the drift is less than one hundred feet deep. Soon after entering Indiana the channel bends to the southwest passing beneath the town Geneva where about four hundred feet of drift are found. Less than three miles west of this town one well disclosed only twenty feet of drift. From Geneva the channel continues in a curve, extending across the northwest corner of Jay coun-

ty, passing two or three miles north of Pennville, and entering into Blackford county. West of Geneva numerous wells show depths ranging from 400 to 440 feet, while just outside of the channel the drift ranges from forty to eighty feet in depth. The length of this channel is nearly 90 miles.

Two tributaries to the channel have been located. The smaller one, extending from the northwest, unites with the main channel near the southwest corner of Harrison township, Blackford county, Indiana. This has not been traced outside of Blackford county. Its depth is as great as that of the main channel. The other tributary unites with the main channel at the west end of Grand reservoir. Running to the southeast from this point successive wells in Mercer county show depths of drift of 260, 300, 382, 315, 298, 402, 400, 455, and 340 feet. Outside of this channel the depths in the same locality range from 45 feet to 135 feet. The channel next cuts across the extreme southwest corner of Auglaize county, furnishing depths of 440, 380, 380, 370, and 400 feet. The drift here outside of the channel does not exceed 90 feet. Entering Shelby county the channel turns to the south, passing just west of the village of Berlin, where a depth of 350 feet was found, with a depth of 100 feet on either side.

The depth of these channels is more than 300 feet below the surface of the rock floor. Usually the walls appear to be steep, and in one case a vertical one was found. This was near St. Marys, Ohio, where, after drilling through 180 feet of drift, rock was struck, but this was found to be less than one foot thick, and then drift was again found. Several projecting ledges of the limestone with drift between, were passed through in this manner, until a depth of 370 feet was reached, when the well was abandoned. As the channel is approached, the drill usually shows a gradual increase in depth of drift until the wall of the channel is met when the increase is very rapid.

The width of the channels can be only approximately given, because the oil wells are not usually sufficiently close together. Besides they are not ordinarily at right angles to the channel. The width appears to be usually about one mile. The greatest found are in the Grand reservoir and at Rockford, where widths of a mile and one-half apparently

exist. Nowhere does the channel appear to be narrower than three-fourths of one mile. The width of the chief tributary seems comparable with the main channel. It is possible that what is regarded as the chief tributary may be the principal channel, and vice versa.

Southeast of Anna few deep wells have been sunk, and the water wells do not reach the rock. Consequently the channel cannot at present be traced beyond that point. It is of interest to note here, however, that at St. Paris, in the western part of Champaign county, a deep well was sunk some years ago, and drift to a depth of 530 feet was passed through without reaching rock. This may lie in the main channel.

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THE OCCURRENCE AND ORIGIN OF DIAMONDS IN CALIFORNIA.*

By H. W. Turner, Washington.

It has long been known that diamonds are occasionally found in the gold placer deposits of California. Prof. J. D. Whitney† and Prof. Hanks have recorded such localities where diamonds have been found as came under their notice. Professor Whitney writes:

"The most interesting mineral found associated with the gold in the gravel of California is the diamond. This gem, as it would appear, is usually, although not universally, found in gravels which are washed or searched with care. Such gravels are chiefly those which are auriferous in character. Hence it follows that diamonds have been found in the surface detritus of most gold regions, as in Siberia, Australia, along the flanks of the Appalachian chain, and in California. * * * It appears that diamonds, like some other natural products, are widely disseminated over the surface of the earth, but are only present in considerable quantity at a very few points. Formerly, India was the productive region; then Brazil had its day; and now South Africa furnishes by far the larger portion of the new diamonds put upon the market. * * * .

The diamond has not been found in sufficient quantity anywhere in North America, whether in the Appalachian or the Californian goldfields, to be of much importance from an economical point of view.

*Published by permission of the Director of the U. S. Geol. Survey.

†Auriferous gravels of the Sierra Nevada, 1879, pp. 362-364, and Prof. Hanks' 4th Ann. Rep. State Mineralogist, 1884, pp. 159-172.

But from the methods pursued in mining in the latter region, it will be easily understood that but few of the diamonds actually contained in the detrital material washed would be likely ever to be seen. Still, the number of localities where this gem has been observed is considerable."

The following is a list of the occurrences as given by Whitney and Hanks:

Diamond Localities in California

Locality	Authority.
Eldorado County, near Placerville.*	
South side of Webber Hill, several	Whitney
White Rock Canyon, three or four	"
Dirty Flat, one	"
Smith's Flat, several?	"
Amador County.	
Jackass Gulch, near Volcano	Whitney
Rancheria, near Volcano	Hanks
Loafer Hill, near Oleta	"
Nevada County.	
French Corral	Whitney
Butte County.	
Cherokee Flat, 56 specimens	"
Yankee Hill	Hanks
Trinity County?	
Trinity River sands (F. Woehler)	"
Del Norte County.	
Smith River sands	"

Recently I have received from Mr. George W. Kimble of Placerville the following information concerning the occurrence of diamonds in his vicinity:

"Most of the diamonds referred to in the letter of Carpenter (see Hanks' report) were found between a point a little south of Smith's flat and White Rock canyon in Neocene river gravels. Thomas Ward and Company's mine is on the south side of White Rock canyon, where it had cut across the Neocene river beds. Cruson & Olmstead's claim adjoins theirs on the south and is known as the Unity mine There has recently been found two more diamonds in Thomas Ward & Company's property since the date of the Carpenter letter."

Mr. Kimble also states that nine more diamonds have quite recently been found in the vicinity, mostly from the Unity mine, and that a great many diamonds have been crushed in

*In a letter to Prof. Hanks loc. cit. p. 169, W. P. Carpenter records the finding of 14 diamonds near Placerville. He probably includes in this list some or all of those noted above.

the gravel mills, for he has frequently examined the concentrates of the mills and found in them fragments of diamonds often so small that they could be determined only by the aid of the microscope. Still more recently (1898) Kimble reports having examined a diamond found within the limits of the town of Placerville, in Cedar ravine, a tributary of Hangtown creek.

Mr. J. A. Edman in a letter reports two localities of diamonds in Plumas county. He found a few in the black sands of Gopher hill, the largest one being 1-20 of an inch in diameter, and on upper Spanish creek in a sand rich in heavy minerals he found two. The Gopher hill locality is in Sec. 7, T. 24 N, range 9 E, and the Spanish creek locality is Sec. 10, T. 24 N, range 8 E, Mt. Diablo meridian.

Mr. George F. Kunz* refers to the finding of two diamonds recently by W. P. Carpenter near Placerville, the larger one of a greenish shade and the smaller pale yellowish, and each nearly ¼ of an inch in diameter. Mr. Carpenter proposes to work his section of the channel by other means and avoid the possible loss of diamonds of more value than the gold. The same writer† notes the finding of a small diamond on the banks of Alpine creek in Tulare county, California, by L. W. Hawkins, and of five diamonds near Oroville in Butte county, and as many more at another locality, suggesting a peridotyte origin. In a later report‡ Mr. Kunz quotes from a writer in the Engineering and Mining Journal, who gives a description of a simple outfit for a miner or prospector looking for diamonds in placers:

A light pick, a shovel, a "miner's wallet," or long bag for carrying the gravel, etc., to water (size 4 feet 8 inches long by a foot and a half across), and two screens or "riddles" with meshes of three-fourths and one-eighth inch, respectively, together with a tub for washing, easily made by cutting a barrel in half, or else a rubber bath tub, and a sheet of rubber cloth to sort the washed gravel upon. To examine it he should have a watchmaker's lens (two powers) and a hardness scale, made by fixing a chip of diamond, one of corundum, and one of quartz, with a lapidary's cement, into the end of a piece of glass tubing or of a pencil from which the rubber has been removed. The lapidary's

*16th Ann. Rep. U. S. G. S. Part IV, p. 596.
†17th Ann. Rep. U. S. G. S. Part III, p. 896.
‡18th Ann. Rep. U. S. G. S. Part V, p 1189.

cement melts easily over a spirit lamp, may then be easily molded with the fingers, and becomes very hard and firm. To examine for diamonds, the coarse riddle is fastened above the fine one, the gravel put into the upper one, and all immersed in the tub and washed and shaken. The coarse stones are retained in the upper riddle, and the sand and earth pass through both into the tub, leaving all the finer gravel in the lower riddle. This latter is detached from the other, and its contents are again washed and shaken, till the heavier portions have settled at the bottom; it is then quickly turned out on the rubber sorting cloth, which should be spread close by. The heavier stones will then be on the top, and may be examined with the lens and the hardness scale.

The California diamonds thus far found are mostly of small size. One found at Rancheria was of a pale straw color and weighed 255 milligrams. A diamond (No. 4033) is in the collection of the State Museum of Mineralogy at San Francisco. This was found at Cherokee. One of the diamonds found at this place is said to have been valued at $250. A diamond found at Yankee Hill is said to be owned by Mrs. John Bidwell, of Chico.

The known occurrence of diamonds in South Africa in serpentine suggests a similar origin for the California finds. If we take the geological maps of the Gold Belt published by the U. S. Geological Survey we will find that there are serpentine masses near all of the localities above reported in the Sierra Nevada. There is no serpentine in place in the gulches in which diamonds were found near Placerville, but Kimble reports that serpentine pebbles were frequent in the diamond-bearing gravels. These serpentine pebbles may easily have come from a point about 6.5 klms. east of Placerville.

It would be interesting, in view of the above facts, if the local gravels of gulches lying entirely in serpentine could be carefully washed and all of the heavy minerals saved and examined. The finding of diamonds in such gulches would strongly suggest that serpentine is the mother rock of the California diamonds, and this might lead to economic results of local importance.

The year 1897 was remarkable in the history of diamond literature for the appearance of three important publications,

by de Launay, Lewis, and Crookes.* De Launay describes the serpentine of the Kimberley mines of South Africa as being derived from a peridotyte determined by Stelzner as a picrite-porphyry. Mixed with the serpentine are abundant fragments of various rocks, so that many specimens are of the nature of a contact-breccia. These serpentine bodies occur as pipes or plugs extending down nearly vertically to an unknown depth. The general shape of the section of each pipe at the surface is round or oval. In following the volcanic plugs down it has been proven that each one passes through several formations. At the surface the enclosing rocks are carbonaceous shales, and at one time it was believed that the carbon composing the diamonds was primarily derived from these shales, and when the excavations passed through the carbonaceous shale it was feared that diamonds would no longer be found. Underlying the shales is a bed of diabase. The serpentine at this horizon still contained diamonds as before. At the present time the excavations or shafts at Kimberley and De Beers have gone through the diabase horizon and the miners are now engaged in working the volcanic pipes in the underlying quartzytes. De Launay states that the enclosing terranes have had no influence whatever either on the quantity or the quality of the diamonds. These have incontestably come from below with the peridotyte-breccia. The idea that the carbon of the diamonds came from the upper carbonaceous shales is thus disproven. Moreover, there are very numerous volcanic chimneys of the peridotyte (kimberlyte) in South Africa, and not all of these contain diamonds, while some contain them only rarely or of microscopic sizes.

De Launay states that the cavities which contain the serpentine pipes are of the nature of volcanic chimneys. Water penetrating to the contact of a molten metallic bath charged with various carburets, caused the sudden formation of carburets of hydrogen, and by their explosion the opening of the volcanic chimneys. The water produced the scorification of the molten peridotyte magma, and by the compression thus exercised on the carbon, the crystallization of the diamonds.

*L. de Launay, "Les Diamants du Cap," Paris, 1897; H. C. Lewis, "Genesis and Matrix of the Diamond," London, New York, and Bombay, 1897; Sir William Crookes "Diamonds," Proceedings of the Royal Institution, Vol. XV, 1897, pp. 477-501.

Finally, water accompanied the eruption of the peridotyte and caused its serpentinization. De Launay in his description of the formation of diamonds in depth evidently has in mind the method of Moissan of forming artificial diamonds, to which, indeed, he refers. This method will be noted further on. While most of the diamonds show their proper crystalline form, there are many broken crystals, but no two fragments found near together ever belong to the same crystal, which clearly indicates transportation, as broken crystals never form in nature. Such broken crystals may be compared to the broken and corroded phenocrysts of igneous rocks, which are regarded as of intratelluric origin. Indeed, according to de Launay, the other original phenocrysts of the peridotyte-breccia, the olivine, garnet, enstatite, etc., likewise give evidence, in their corroded and broken forms, of having crystallized in depth.

Lewis does not appear to have visited South Africa himself, and his book is largely taken up with a description of the diamond rock and the fragments of other rocks included in it. Some of his conclusions, therefore, have not the value of those of de Launay or of Crookes. According to Lewis the diamonds are crystallized in sharp octahedrons and dodecahedrons. Carbonados and black diamonds are not only found in large crystals but are very common as minute and almost microscopic crystals. The abundance of these crystals is another proof that they are not inclosures brought up from some other matrix. Lewis states that only the peridotyte that is full of fragments of shale and other impurities contains the diamonds.* These shales are highly carbonaceous so that they burn readily. The fragments of shale enclosed in the peridotyte are more compact and have lost their shaly character, their bituminous or carbonaceous matter, and their sulphur. The microscope shows also that they have frequently been mineralogically altered by the heat of the lava and become filled with aggregates of micaceous minerals.

Lewis gives the following minerals as occurring in the peridotyte (kimberlyte): olivine, enstatite, chrome-diopside, smaragdite, biotite, garnet, perovskite, magnetite, chromite, ilmenite, picotite; and more rarely apatite, epidote, orthite,

*Judging from the description of de Launay, this is an error.

tremolite, tourmaline, rutile, sphene, leucoxene; also an undetermined mineral, probably cyanite (disthene); and finally diamond. The olivine is often said to be fresh; the biotite is a prominent ingredient. Serpentine, in part bastite, calcite, zeolites,chalcedony, and talc occur as decomposition products. One occurrence of native gold in a Kimberley diamond is on record. This has been reported by Becker.* This diamond is now in the Royal Polytechnic High School at Aachen.

Sir William Crookes, who visited South Africa early in 1896, a few months after de Launay, treats of the origin of the diamond more from a physical standpoint, placing great stress on the method of formation of artificial diamonds by M. Moissan, who used iron as a solvent for the carbon. The iron, which must be thoroughly purified, is placed in a carbon crucible together with charcoal made from sugar, and the crucible subjected to a temperature of 4000°C in an electric furnace. As is well known, iron increases in volume at the moment of passing from the liquid to the solid state. The sudden cooling solidifies the outer layer of iron and hold the inner molten mass in a tight grip. The expansion of the inner liquid on solidifying produces an enormous pressure, and under the stress of this pressure the dissolved carbon separates out in a transparent, dense crystal; in fact as diamond.

Many circumstances point to the conclusion that the diamond of the chemist and the diamond of the mine are strangely akin as to origin. It has been conclusively proven that the diamond has not been formed *in situ* in the peridotyte-breccia. The diamond genesis must have taken place at great depth under enormous pressure. The explosion of large diamonds on coming to the surface shows extreme tension. There were probably many types of crystallization; differing in place and time, or we should not see such distinct characteristics in gems from different mines, nor, indeed, in the diamonds from different parts of the same mine.

The finding of diamonds in meteorites is also utilized by Crookes as further evidence of the origin of diamonds in association with iron. Moreover, iron is the most abundant impurity found in the ash of diamonds after they have been burned. Crookes regards the diamond as having been formed

*George F. Becker, 16th Ann. Rep. U. S. G. S., No. 3, p. 272.

in a laboratory buried at vastly greater depths than we have reached or are likely to reach, where the temperature is conformable with that of the electric furnace, where the pressure is fiercer than in our puny laboratories and the melting point higher, where no oxygen is present, and where masses of carbon-saturated iron have taken centuries, perhaps thousands of years, to cool to the solidifying point.

The method of the formation of the volcanic orifices, which were subsequently filled with the peridotyte-breccia, is considered by Crookes as possibly explained by the erosive action of escaping gases. Through a cylinder of granite a hole was drilled 2-10 of an inch in diameter. This cylinder was made the stopper of an explosive chamber in which a quantity of cordite was fired, the gases escaping through the vent in the granite cylinder. The pressure was about 1,500 atmospheres, and the whole time of escape was less than half a second. Nevertheless, the erosion produced by the escaping gases and by the heat of friction, scoured out a channel half an inch in diameter and melted the granite along the orifice. If granite is "thus vulnerable at comparatively moderate gaseous pressure, is it not easy to imagine the destructive up-burst of hydrogen and water gas, grooving for itself a channel in the diabase and quartzyte, tearing fragments from resisting rocks, covering the country with debris, and finally, at the subsidence of the great rush, filling the self-made pipe with a water-burned magma in which rocks, minerals, iron oxide, shale, petroleum, and diamonds are churned together in a veritable witches' caldron?"

Crookes regards the peridotyte-breccia more as a mud lava than as a true igneous intrusion. While de Launay supposes water vapor to have accompanied the eruption of the peridotyte, he nevertheless regards it as an igneous intrusion, and Lewis likewise appears in the main to take the same ground, although he regards some of the material as a tuff. The specimens of kimberlyte that were shown in the collection of George F. Kunz at the Chicago Exposition certainly presented all the appearance, both megascopically and in thin section, of a serpentine derived from a peridotyte-porphyry, and the description of the rocks by Lewis and de Launay clearly shows that a large portion of it is serpentine derived

from an olivinitic lava, and is not of the character of mud lava or tuff. Peridotytes resembling kimberlyte have been found in the United States at Syracuse, N. Y.,* and Elliott county, Kentucky.† So far as known no diamonds, however, have been found in the vicinity of these peridotyte masses. None of the serpentines of California, so far as my information goes, are of the kimberlyte type. The association of the diamonds with serpentine may perhaps be due to the usually higher content of iron in these basic rocks. Diamonds might therefore be expected in any of the more basic igneous rocks.

However, it is by no means certain that diamonds are not formed under very different conditions from those described by Crookes. In a recent paper‡ Derby writes of the occurrence of diamonds in Brazil. Derby states that for the question of genesis the most significant of the Brazilian localities is that of Sao Joao de Chapada near Diamantina. The diamonds occur here in thoroughly decomposed material, no absolutely fresh rock being found. So far as can be made out from observations on material the most unsatisfactory that can be imagined, the most plausible hypothesis as regards the various clays of Sao Joao da Chapada is that they represent a group of phyllytes of varied character but principally if not exclusively of clastic origin threaded with dikes of pegmatyte. The clastic origin of the schists is regarded probable from the worn character of the zircons found in the clay derived from the schists. The diamond-bearing streaks appeared to Derby to contain distinct bands composed in part of quartz, with plates of specular iron, and these bands he suggests may be pegmatyte dikes. The primary tourmaline and zircon and the secondary hematite and rutile found in the heavy residue after washing the clay are supposed to have originated in the pegmatyte, the hematite, anatase, and rutile having formed from original iron and titanium minerals now gone. The staurolite and disthene found in the heavy residue are supposed to have come from the schists where they may have formed as a result

*G. H. Williams, Am. Jour. Sci. Vol. XXXIV, 1887, p. 137.

†J. S. Diller, Bull. 38, U. S. Geol. Survey, 1887.

‡Brazilian evidence on the genesis of the diamond, Jour. of Geol Vol. VI, 1898, pp. 121-146.

of contact metamorphism induced by the intrusive pegmatyte. Derby is inclined to think that the diamonds have come from the schists along the borders of the pegmatyte dikes and not from the dikes themselves. In other words, he appears to regard it possible that the diamond is a product of contact-metamorphism. Moreover, he states that no rocks of the peridotyte series have been found in direct association with the diamond-bearing beds at any point in Brazil. He lays some stress on the occurrence of tourmaline and disthene in fragments of schist in the South African peridotyte-breccia. Disthene is characteristic of schists, and tourmaline often so; and, as de Launay states that there are schists mingled with the lower quartzytes in the mines of South Africa from which the schist fragments in the breccia were probably derived, Derby suggests a possible analogy between the South African deposits and those of Brazil. He considers that in order to bring the Kimberley and Brazilian modes of occurrence into line as facies of a single mode of genesis, it seems necessary to put aside the idea that the recent interesting experiments on the artificial production of the diamond afford a solution of its terrestrial origin and also that the Kimberley type of rock and mode of occurrence are essential features, Derby would thus suggest the origin of the South African diamonds in the underlying schists as a result of igneous intrusions, a very unlikely hypothesis in light of the investigations of Lewis, de Launay, Crookes, Moissan and others indicating the deep seated origin in molten material. It is regarded as certain by Derby that the Brazilian diamond must have had a different origin from that now ascribed to the South African occurrences.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

South Dakota Geological Survey, Bulletin No. 2: The First and Second Biennial Reports on the Geology of South Dakota, with Accompanying Papers. BY JAMES E. TODD, State Geologist. (Pages viii. 139; with 15 plates, and two figures in the text. 1898.)

This publication gives a history of the survey from its beginning in 1893. The state appropriation has been only $250 yearly, but, with aid from the State School of Mines, much good work in exploration and publication has been accomplished. Biennial administrative reports bearing dates in 1894 and 1896 are here first published, with six papers by the state geologist, on special areas and subjects investigated.

The first paper, in 14 pages, describes the "Section along Rapid creek from Rapid City westward." This section, within a distance of ten miles, passes from the Cretaceous series to the folded pre-Cambrian slates and quartzites which form this part of the nucleus of the Black Hills.

In pages 42-68, with plates v-x, on "A Reconnaissance into Northwestern South Dakota," the geology of the part of the state north of the Black Hills is summarized with notes of numerous sections. The detailed geology of this district was hitherto almost entirely unknown. It consists of Cretaceous and Tertiary formations, from the Dakota to the Loup Fork beds. Deposits of lignite, up to 10 feet in thickness, were found, which may be of economic value when the country shall be more fully settled.

The other papers are as follows: "The Geology along the Burlington and Missouri railway" (pp. 69-82), which passes northward through the Black Hills to Deadwood; "Elevations in and about the Black Hills" (pp. 83-87); "Additional Notes on the Limits of the Main Artesian Basin" (pp. 88-116), having reference to the region, including the James river valley, that can obtain artesian water from the Dakota sandstone, and giving the section record or log of many wells, with a map of the contour of the "bed rock" in the best known part of this artesian basin, based on the earlier map by Darton; and "The Exploration of the White River Bad Lands in 1896" (pp. 117-135, with plates xii-xv), including observations of formations ranging from the Dakota to the Pleistocene and Recent.

W. U.

Is the Loess of Aqueous Origin? By B. SHIMEK. (Pages 14: reprinted from the Report of the Iowa Academy of Sciences, 1897.)

This question is considered according to the evidence of the fossil mollusca of the the loess of Iowa, Nebraska, and Missouri. Professor Shimek compares his very large collection of these fossils with the modern representatives of the same species, all of which are still found living in that region, and indeed, with only three or four exceptions, these species are found within the territory covered by the loess.

The number of specimens of aquatic or semi-aquatic mollusca from the loess in this collection, shown in a table at the end of the paper, is 771, of which 750 belong to the pulmonate genus Limnæa. The great majority are L. humilis Say, which at present, is "quite as frequently found out of the water as in it," being "abundantly developed in ponds and streams which are dry during the greater part of the summer."

There are 4,816 specimens of fossil terrestrial molluscs in Prof. Shimek's collection, of which 1,714 belong to three species of Succinea, S. avara, S. lineata, and S. obliqua, which are often found at the present time in high and very dry situations. The temperature and rainfall of the region during the deposition of the loess must have been nearly as now, permitting the growth of abundant plant-food for these herbivorous land molluscs. The author therefore writes: "Summing up the evidence of the fossils, we may assert that it points to conditions not unlike those which exist to-day, and that geologists, in seeking for the cause and manner of the deposition of the loess, must give up the assumption of widely submerged areas over which fossiliferous loess now occurs, and of a cold climate."

Although direct consideration of the mode of formation of the loess is not taken up by the author, further than the statement that its materials originated largely or wholly in drift, he apparently holds the same view as Udden and Sardeson, that the loess is chiefly of land deposition by wind action. While this seems to the reviewer a good explanation of the derivation of the loess upon many tracts, including those high above the valleys and plains, a much greater part of the loess, spread continuously along the broad avenues of drainage from the melting ice-sheet in its recession from its Iowan reädvance, seems to be referable to fluvial or sometimes lacustrine deposition, as shown by Chamberlin in his discussion of the partly æolion origin of this formation.

With the depression of the glaciated area from its former high altitude, to which the snowy climate producing the ice-sheet appears to have been due, there was doubtless restored on the land bordering the ice nearly as genial climatic conditions as are now enjoyed by the same areas. The reviewer thinks that great floods from the ice-melting then filled the valleys and spread over wide flood-plains during a few weeks of each summer, and that these plains, covered thinly each season with new loess of such aqueous deposition, were clothed through each autumn and spring with vegetation, affording favorable conditions for the land molluscs whose shells are the predominant fossils of the loess. W. U.

Maryland Geological Survey, Vol. II, 1898. WM. BULLOCK CLARK, State Geologist.

The second volume of the Maryland Geological Survey admirably meets the expectations aroused by the first report from that survey.

There is the same standard of excellence in the typographical work, in the illustrations and in the general appearance of the volume, while the 500 pages of text contain additional information of manifest practical value. More thorough and complete discussion of certain of

the physical features of Maryland than was possible at the time the first report was issued is presented in this volume and the results of investigations carried on since the establishment of the Survey are treated in a way that cannot be otherwise than instructive to the citizen of Maryland. Forty-eight plates and thirty-four figures furnish full and exceedingly varied illustrations.

The subjects treated are the Building and Decorative Stones and the Cartography of Maryland, and their discussion comprises parts II and III of the volume. An administrative report by the State Geologist forms Part I and contains an account of the operations of the survey during 1896 and 1897 and recent additional legislation.

The state survey has been fortunate in the co-operation of the Federal survey and, by this means, has been able to push the topographical work rapidly. During 1896, 650 square miles were surveyed and a considerable area was added to this in 1897.

The magnetic division of the survey, in charge of Dr. Bauer, has established 76 new stations, which, with the 28 stations formerly established by the U. S. Coast and Geodetic Survey, make an average of one station to every 118 square miles in the state.

The more purely geological work of the survey during the first two years of its existence comprises a preliminary survey of the entire state, some detailed areal work on the coastal plain, the Piedmont plateau and in the Appalachian region, an economic investigation of the building stones of the state and the inauguration of hydrographic. agricultural and statistical investigation. In the hydrographic work the survey was again fortunate in the co-operation of the U. S. Geological Survey and the investigation of the building stones was conducted with the assistance of Dr. Merrill of the U. S. National Museum.

The General Assembly of 1898 set its approval upon the survey by the continuation of appropriations and by the enacting of additional legislation, making provision for the extension of the topographic survey and for the investigation of the question of highway construction.

The report on the building and decorative stones of Maryland by Dr. Merrill and Dr. Mathews is admirably fitted to be of service to quarry-operators and contractors alike. General geological conditions, the strength of stones, the geographic distribution of the building stones of the states, methods of quarrying and working, with full discussion and illustration of machinery employed, the relation of Maryland to other producing areas, the durability and methods of testing building stones, are subjects treated by Merrill, who speaks authoritatively on physical and economic properties of building stones.

A more detailed description of the character and distribution of Maryland building stones, together with a history of the quarrying industry is given by Mathews. These descriptions are suited to the quarrier and to the intelligent citizen and are both clear and accurate. The illustrations of the polished surfaces of the more important build-

ing stones and the photomicrographs which illustrate his paper. are excellent.

The Maryland survey is fortunate in securing for its report the paper by Mr. Gaunett on the aims and methods of cartography with especial reference to the topographical maps now under construction in Maryland. This paper is a complete presentation of the best modern topographic methods and is a source of reliable information to the practical surveyer and the means of enabling any citizen to use intelligently the maps of the state.

The historical treatise, with which the report closes, on the maps and map-makers of Maryland, by Mathews, is illustrated by reproductions of some of the early maps, notably the famous Smith map. Lord Baltimore's map and Herman's map. The text and the maps are remarkably interesting and compel an admiration for the geographical insight as well as for the fortitude of the early map-makers.

For the first time in her history Maryland is able, through her survey in co-operation with the U. S. Geological Survey, to furnish rapidly a series of wholly satisfactory topographical maps of the state. Within a few years the entire state will thus be mapped upon a large and uniform scale. F. B.

Geology of the Lake Placid Region. By J. F. KEMP. (Bull. New York State Museum, vol. 5, no. 21, pp. 47-67, 1 map, 1 pl., Sept, 1898.)

The Lake Placid region lies to the northwest of the great central group of peaks which constitutes the back bone of the Adirondacks. In the description here presented "it has been the writer's aim to give an observer, and especially a teacher, who might be sojourning in the region, a grasp of its larger geologic features, and to suggest the topics in regard to which our present knowledge needs amplification." In addition to the comparatively recent deposits from ice and water, the rocks of the district are crystalline limestone, quartzyte, granite, gneiss, anorthosyte and later trap dikes. Each of these is described and the geologic history of the region is outlined. All the rocks, except the trap dikes, are referred to the Algonkian, and the dikes may be pre-Potsdam or even as late as the Utica. The paper is accompanied by a geological and topographical map and by a relief map.

U. S. G.

Fossil Plants, for Students of Botany and Geology. By A. C. SEWARD, Cambridge Natural Science Manuals, Biological Series. Pp. VIII, 452. New York: The McMillan Co. Price $3.00, net.

Both the extension and the refinement of paleophytological investigation have been so rapid during the last twenty-five years that manuals and text-books, like censuses, have been valuable, according to the perfection of the author's labor, only as indicating the systematic status of the science for the brief periods following their publication. It is therefore largely a labor of love and self-sacrifice when the paleobotanist sets himself at the task of preparing an educational systematic book which shall at once give the results of the most recent studies

and revisions, while covering the whole vegetable kingdom and all post-Archæan time. Yet, in the surprisingly rapid evolution of paleobotany, however short-lived the reign of each new-comer, such works are more than useful; they are a necessity.

After reading and comparing Seward's "Fossil Plants," the first volume of which has been printed in the Cambridge Natural Science Manuals, it is not too much to say that it is by all odds the best general work, viewed from all standpoints, that has yet appeared, besides which it is quite up to date. Unlike Schimper, Schenk, and Renault, who wrote for the systematic paleobotanist, or Solms-Laubach, whose discussions and histological interpretations, confined for the most part to Paleozoic plant types, are of special value only to the botanist or the paleobotanist, Dr. Seward has written at once for both geologists and botanists. He has endeavored to impart to his fellow-botanists a broad view of time, an appreciation of the nature of vegetable remains, their modes of fossilization and occurrence, and the difficulties attending their identification, while making them acquainted with the various extinct types and their assumed or ascertained relations to the living plant world. At the same time he is careful to explain to geologists the relation of the chain of fossil plant life to living types, while discussing the organization and probable nature of the classes of organisms met in the various formations. His method is to give lucid, well-illustrated descriptions, somewhat in detail, of the principal types, with such brief references to and illustrations of others as may guide the students in further inquiry on the one hand, while noting the principal forms of each geological period on the other.

In his discussion of the relations of fossil to living types Seward is less philosophical and far less speculative than Saporta, who wrote chiefly for botanists. In fact, while he shows thorough familiarity with the literature of his subject and a wide range of reading in cognate fields, he appears possibly unnecessarily cautious. He is not only more conservative than most authors as to the genetic relations of the types, but he even appears to have less confidence than most of his colleagues in the value of fossil plants either in stratigraphic correlation or as tests of climate.

Of the four hundred and fifty pages in this, the first volume, the first hundred are occupied with preliminary discussions of elements for the geologist and the botanist. The remainder of the volume includes the treatment of the lower orders of Cryptogams, followed by the Equisetales and the Sphenophyllales, the latter being thus recognized as a distinct class. The systematic arrangement, on the lines of the system adopted by Engler and Prantl, is probably the best that has ever been presented.

The work contains descriptions of several new species and of one new genus, Sphenophyllostachys, for the "cones" of Sphenophyllum. The great preponderance of the types discussed in the present volume are Paleozoic, as is natural since only the lowest classes are treated.

The second volume of the work, in which we are promised a discussion of the question of the formation of coal, should be much larger than the first, if the treatment of the classes in the Lycopods, Gymnosperms, and Angiosperms is proportionate to that of the Algæ and Calamariæ in the first volume. It should be remarked that the sections on these two groups of fossil plants are especially valuable and interesting. The first is conservative, critical, yet thorough and discreet. The presentation of the second group, in which Seward follows the British and German paleontologists by including Calamopitys and Arthropitys, is well balanced, complete and very instructive. The work shows a wide range of learning, and thorough conversance with the particular subject. The method of treatment is original, the style is clear and concise, and the illustrations are excellent as well as profuse, a large number being new.

As indicated above, Dr. Seward's work is not only abreast of paleobotanical progress up to date, but it is probably the best popular manual on the subject in existence. Considering the dual character of his audience it is probably as successful a work as lies in the power of any one living man. The author of this review does not, however, regard it as most practicable to write to both geologists and botanists in the same manual. Too great an amount of energy and time are necessarily consumed in botanical elementaries for the geologist, and in geological fundamentals for the botanist. Of course they are needful; indeed they are most beneficial, but each to its class. In the writer's opinion the need of the general geologist and stratigrapher is for a work which shall present in comprehensive view the sequence of plant life on the globe with special reference to the generic composition (briefly systematized) of the floras of each period, and particularly for profusely illustrated groups to show the species characteristic of each period, stage, or formation, so refined as may be practicable, from the Cambrian onwards, accompanied by a brief statement of some of the distinctive characters of the species and their vertical range, with appropriate phylogenetic references to recent types which the reader may then consult in proper botanical repositories. Nothing, on the other hand, can be of more value to botany at the present day—when so many botanists have turned to phylogenetic speculation and are groping, often in ignorance of paleobotanical discoveries, in search of lines of descent and a more natural system of plant classification—than to impart to students of living plants some proper conception of the value of geologic time, and the proportions of the eras and periods during which certain types existed while bringing to their attention what is known as to the floras of the successive periods, the first appearance of types and their sequence, with all available histological data and, if you will, speculation, from the paleontological standpoint as to their genetic relations.

D. W.

The Richmond Folio:-Folio 46, U. S. Geological Survey, 1898. Geology by MARIUS R. CAMPBELL, assisted by JOSEPH A. TAFF and WALTER C. MENDENHALL.

This folio, just issued, the first to treat of an area entirely within the limits of Kentucky, is uniform in plan and character with the other folios dealing with the geology of the southwestern Appalachian province.

The quadrangle, 944.2 sq. mi. in extent, and bounded by the parallels of 37° 30′ and 38° and the meridians of 84° and 84° 30′, has Richmond, the county town of Madison county, very nearly in the center. The quadrangle includes, besides Madison, parts of the surrounding counties of Clark, Estill, Jackson, Rockcastle, Garrard, Jessamine and Fayette.

The discussion of the topography affords Mr. Campbell (an ardent "peneplainist") an opportunity to interpret the relief features in the southwestern Appalachians and adjacent regions to the west in accordance with the advanced views of the now dominant school of American physiography.

Evidence of two peneplains of different ages—the one provisionally considered Cretaceous and the other Eocene—is found within the limits of this quadrangle. The facts and arguments here so clearly and forcibly presented, constitute a valuable contribution to physiographic geology. To a few geologists, however, who are still doubting Thomases as regards this doctrine of oft recurring peneplains, the evidence of more than one cycle of erosion in this region may appear inconclusive. Some doubtless will still prefer to explain these plains or plateaus, (there are really more than two—one for every marked lithological change in formation) lying at different levels and dissected, as but the expression of atmospheric denudation acting through one long cycle of erosion upon rock formations, differing in hardness and other characters. The successive geologic age assigned these plains in accordance with the peneplain theory may be granted, if we are allowed to understand that it is not age at which a certain stage in an erosion cycle was reached that is meant; but age during which topographic features were determined by exposing to erosion fresh rock surfaces differing in character from that which had to be denuded in order to bring these new surfaces into view. Accordingly we are inclined to see in Mr. Campbell's "Cretaceous peneplain" in Kentucky Carboniferous strata, afterwards elevated and now found 500 feet above the Lexington or Eocene peneplain, simply the remnant of what perhaps as late as Cretaceous time was a continuous sheet of fairly homogeneous strata lying well up upon or over the Lexington dome; and by the "Lexington Eocene Peneplain" we are disposed to understand an area of Silurian rocks which began to be uncovered and to attain a considerable extent during Eocene time.

That the whole country in question was once reduced by denudation to a relatively low level—base leveled if you please—there can be little question. Mr. Campbell's review of the evidence upon which this con-

clusion is based is quite convincing, and the date—Pleistocene—assigned for the uplifting seems probable.

In describing the stratigraphic series, which embraces the formations from lowest Ordovician (Chazy) to the Lower Coal Measures (Pottsville), some new names of a local character are now introduced for the first time in Kentucky geology.

These in ascending order are: "*Highbridge limestone*"; correlated with the Chazy and Birdseye of New York, following Linney, though there is a disposition to ignore the importance of Linney's distinction here. The thickness, ten feet, as assigned to the whole Birdseye, is too low. It should be 130 feet.

"*Lexington limestone*" equals "Trenton" of the Kentucky Reports.

"*Flanagan chert*" equals "Hudson chert" of the Kentucky Reports.

"*Winchester limestone*" equals "Lower Hudson" of the Kentucky Reports.

"*Garrard sandstone*" equals "M. Hudson sandstone" of the Kentucky Reports.

"*Richmond shale*" equals "Upper Hudson sandstone" of the Kentucky Reports.

This term refers to Richmond, Indiana, not Richmond, Kentucky, as one would naturally think, if it were not for the explanation that it is adopted upon the authority of Mr. E. O. Ulrich, who has used the term as descriptive of this portion of the series in Indiana.

"*Panola formation*" equals U. Silurian and Corniferous of the Kentucky Reports.

"*Irvine formation*," correlated with Neocene deposits. This formation was never noted in the Kentucky reports.

The formations between the Panola Formation and Irvine Formation are given for the most part the same names as those in Virginia and Tennessee with which they are correlated; namely—

"*Chattanooga shale*" equals "Ohio black shale" of Kentucky Reports.

"*Waverly shale*" (adopted from Ohio) equals "Waverly shale and sandstone" of Kentucky Reports.

"*Newman limestone*" equals "St. Louis limestone" of Kentucky Reports.

"*Pennington shale*" equals "Chester ?" of the Kentucky Reports.

"*Lee formation*" with its sandstone lenses equals "Coal Measure conglomerate" or "Rockcastle Series" of the Kentucky Reports.

The mineral resources of this area are not great, hence treatment of the economic geology is brief. Some coal occurs in the southeastern corner of the quadrangle. Limestones for building purposes and road metal are well distributed over the area:—the best building stones being those from the Kentucky river cliffs,—the so-called "Kentucky River marble." Brick and pottery clay are widely distributed: the best being near Waco—the "Waco clays." These are considered residuals from the weathering of the "Panola formation." Is it not rather likely that they are the "Neocene clays" of the "Irvine Formation?" Proper mention is made of the "phosphate deposits" and their

relation to the fertility of the soil in the "blue grass" region. There is a good discussion of the soils and in the tabular statement at the close of the sketch an excellent resumé of all the leading facts of geology presented in the text.

The London Folio.—Folio 47, just received, follows the Richmond folio in series. The quadrangle joins the Richmond quadrangle on the south. The area embraced is 950.4 square miles. Topography and geology are by the same persons as the preceding. On account of the similarity in geologic features, much of the description appearing in the former folio is applicable here and is repeated. The same general interpretation of topography is here adhered to, but the introduction of a "structural plain" intermediate in hight and age between the Cretaceous and Eocene peneplains might be looked at in the light of a concession to a growing opposition in the minds of geologists to the theory of a multiplicity of peneplains.

The age of the Cincinnati uplift is discussed and the conflicting opinions presented, but no positive opinions of the author are advanced except that land surface must have existed in this region at the end of Silurian and again at the end of Lower Carboniferous time. The evidence in favor of the existence of these late Silurian and early Carboniferous "Cincinnati islands" is cited, and the possibility of their resumbergence during late Carboniferous time is deemed not unlikely.

The geological range of formations is not so great as in the Richmond quadrangle. The series commences with the Panola Formation in the Upper Silurian and ends with the Breathitt in the lower Coal Measures. The Silurian and Devonian areas are limited to a small outcrop in the extreme northwestern corner of the quadrangle. Coal Measure strata form two-thirds of the surface outcrop. Taken as a whole the region is strictly non-agricultural, the soils being thin and poor and the country rugged. There are some commercial coal mines in the eastern part of the area. Probably the most interesting contribution to stratigraphic geology is the determination of the existence of two conglomerates in this region:—"the Rockcastle and Corbin conglomerate lentils." Attention is called to a fine instance of an erosion channel (contemporaneous erosion?) through Pennington shale into Newman limestone, which has been filled by gravel of Rockcastle conglomerate lentil age. Its existence is made to support the view of an erosion interval at the close of Lower Carboniferous time.

The sketch closes with a resumé of the chief facts of the geology presented in the usual tabular form, in which also the Kentucky survey equivalents for the new names proposed are given. A. M. M.

MONTHLY AUTHORS' CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

Aguilera, J. G.

Essai d'une évolution continentale du Mexique. (Bull. Soc. Géol. de France, ser. 3, vol. 36, pp. 512-516, 1898.)

Bain, H. F., and Leonard, A. G.

Middle Coal Measures of the western interior coal fields. [Abstract.] (Bull. Geol. Soc. Am., vol. 10, pp. 10-12, Jan. 28, 1899.)

Case, E. C.

The development and geological relations of the vertebrates. IV. Aves. V. Mammalia. (Jour. Geol., vol. 6, pp. 816-839, Nov.-Dec. 1898.)

Clements, J. M.

A contribution to the study of contact metamorphism. (Am. Jour. Sci., ser. 4, vol. 7, pp. 81-91, Feb. 1899.)

Cope, E. D.

Vertebrate remains from the Port Kennedy bone deposit. (Jour. Acad. Nat. Sci. Phila., vol. 11, pt. 2, pp. 193-267, pls. 18-21, Feb. 4, 1899.)

Daly, R. A.

The peneplain—a review. (Am. Nat., vol. 33, pp. 127-138, Feb. 1899.)

Eckel, E. C.

Intrusives in the Inwood limestone of Manhattan island. (Am. Geol., vol. 23, pp. 122-124, pl. 3, Feb. 1899.)

Foote, H. W. (Penfield, S. L., and)

On the chemical composition of tourmaline. (Am. Jour. Sci., ser. 4, vol. 7, pp. 97-125, Feb. 1899.)

Gilbert, G. K.

Bowlder-pavement at Wilson, N. Y. (Jour. Geol., vol. 6, pp. 771-775, pl. 14, Nov.-Dec. 1898.)

Gilbert, G. K.

Recent earth movement in the Great Lakes region. (U. S. Geol. Survey, 18th Ann. Rept., pt. 2, pp. 595-647, pl. 105, 1898.)

Greene, G. K.

Contribution to Indiana palæontology. Pt. II. (Pp. 8-16, pls. 4-6; Ewing and Zeller, New Albany, Ind., Jan. 20, 1899.)

Gresley, W. S.

Side-light upon coal formation. (Am. Geol., vol. 23, pp. 69-80, pl. 2, Feb. 1899.)

*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Gulliver, F. P.

Shoreline topography. (Proc. Am. Acad. Arts and Sci., vol. 34, no. 8, pp. 149-258, Jan. 1899.)

Gulliver, F. P.

Classification of coastal forms. [Abstract.] (Bull. Geol. Soc. Am., vol. 10, p. 18, Jan. 28, 1899.)

Gulliver, F. P.

Note on Monadnock. [Abstract.] (Bull. Geol. Soc. Am., vol. 10, p. 14, Jan. 28, 1899.)

Hamilton, S. H.

The occurrence of marcasite in the Raritan formation. (Proc. Acad. Nat. Sci. Phila., 1898, p. 485.)

Haworth, Erasmus.

Kansas University Geological Survey. (Am. Geol., vol. 23, p. 35, Feb. 1899.)

Hobbs, W. E.

Some new fossils from eastern Massachusetts. (Am. Geol., vol. 23, pp. 110-115, Feb. 1899.)

Hollick, Arthur.

Some features of the Staten Island drift, New York. [Abstract.] (Bull. Geol. Soc. Am., vol. 10, pp. 2-4, Jan. 28, 1899.)

Hollick, Arthur.

The relation between forestry and geology in New Jersey. (Am. Nat., vol. 33, pp. 1-14 [illegible], Feb. 1899.)

Hopkins, T. C.

Clays and clay industries of Pennsylvania. [illegible] Pennsylvania [illegible] part. (Appendix to Ann. Rept. Penn. State [illegible] 1897, pp. [illegible] 1898.)

Hovey, E. O.

[illegible] winter meeting of the Geological Society of America. [illegible] Feb. 1899.

Ingall, E. D.

[illegible]

Kemp, J. F.

[illegible]

Kemp, J. F.

[illegible]

Keyes, C. R.

[illegible]

Kümmell, H. B.

The Newark rocks of New Jersey and New York. (Jour. Geol., vol. 7. pp. 23-52, Jan.-Feb. 1899.)

Kuntze, Otto.

On the occurrence of quenstedtite near Montpelier, Iowa. (Am. Geol., vol. 23, pp. 119-121, Feb. 1899.)

Lane, A. C.

Note on a method of stream capture. (Bull. Geol. Soc. Am., vol. 10, pp. 12-15, Jan. 28, 1899.)

Lane, A. C.

Magmatic differentiation in rocks of the copper-bearing series. [Abstract.] (Bull. Geol. Soc. Am., vol. 10, pp. 15-18, Jan. 28, 1899.)

Leith, C. K.

Summaries of current North American pre-Cambrian literature. (Jour. Geol., vol. 6, pp. 840-854, Nov.-Dec. 1898.)

Leonard, A. G. (Bain, H. F., and)

Middle Coal Measures of the western interior coal fields. [Abstract.] (Bull. Geol. Soc. Am., vol. 10, pp. 10-12, Jan. 28, 1899.)

Leverett, Frank.

The lower rapids of the Mississippi river. (Jour. Geol., vol. 7, pp. 1-22, Jan.-Feb. 1899.)

Logan, W. N.

A discussion and correlation of certain subdivisions of the Colorado formation. (Jour. Geol., vol. 7, pp. 83-91, Jan.-Feb. 1899.)

Luquer, L. McI.

Minerals in rock sections. The practical methods of identifying minerals in rock sections with the microscope, especially arranged for students in technical and scientific schools. (vii and 117 pp.; D. Van Nostrand Co., New York, 1898.)

Merritt, F. J. H.

A guide to the study of the geological collections of the New York State Museum. (Bull. N. Y. State Museum, vol. 4, no. 19, pp. 105-262, pls. 1-118, 1 map, Nov. 1898.)

Osborn, H. F.

A complete skeleton of Teleoceras fossiger. Notes upon the growth and sexual characters of this species. (Bull. Am. Mus. Nat. Hist., vol. 10, pp. 51-59, pls. 4-4A, 1898.)

Osborn, H. F.

A complete skeleton of Coryphodon radians. Notes upon the locomotion of this animal. (Bull. Am. Mus. Nat. Hist., vol. 10, pp. 81-91, pl. 10, 1898.)

Osborn, H. F.

Remounted skeleton of Phenacodus primævus. Comparison with Euprotogonia. (Bull. Am. Mus. Nat. Hist., vol. 10, pp. 159-164, pl. 12, 1898.)

Osborn, H. F.

Evolution of the Amblypoda. Part I. Taligrada and Pantodonta. (Bull. Am. Mus. Nat. Hist., vol. 10, pp. 169-218, 1898.)

Osborn, H. F.

Additional characters of the great herbivorous dinosaur Camarasaurus. (Bull. Am. Mus. Nat. Hist., vol. 10, pp. 219-233, 1898.)

Osborn, H. F.

The origin of Mammals. (Am. Jour. Sci., ser. 4, vol. 7, pp. 92-96, Feb. 1899.)

Osborn, H. F.

Frontal horn on Aceratherium incisivum. Relation of this type to Elasmotherium. (Science, new ser., vol. 9, pp. 161-162, pl. 1, Feb. 3, 1899.)

Penfield, S. L., and Foote, H. W.

On the chemical composition of tourmaline. (Am. Jour. Sci., ser. 4, vol. 7, pp. 97-125, Feb. 1899.)

Reid, H. F.

Stratification of glaciers. [Abstract.] (Bull. Geol. Soc. Am., vol 10, p. 4, Jan. 28, 1899.)

Russell, Frank.

Human remains from the Trenton gravels. (Am. Nat., vol. 33, pp. 143-156, Feb. 1899.)

Selwyn, A. R. C.

Eminent living geologists: Alfred Richard Cecil Selwyn. (Geol. Mag., new ser., dec. 4, vol. 6, pp. 49-55, pl. 2, Feb. 1899.)

Smith, J. P.

Geographic relations of the Trias of California. (Jour. Geol., vol 6, pp. 776-786, Nov.-Dec. 1898.)

Squier, G. H.

Studies in the driftless region of Wisconsin. (Jour. Geol., vol. 7, pp. 79-82, Jan.-Feb. 1899.)

Stanton, T. W.

Supplement to the annotated catalogue of the published writings of Charles Abiathar White. (Proc. U. S. Nat. Museum, vol. 20, pp. [illegible]-642, 1898.)

Tyrrell, J. B.

The geology of the Klondike region. (Eng. and Mining Jour., [illegible] Jan. 28, 1899.)

Udden, J. A.

The Sweetland Creek beds. (Jour. Geol., [illegible] Jan.-Feb. 1899.)

Upham, Warren.

Evidences of epeirogenic movements causing and terminating the Ice age. (Bull. Geol. Soc. Am., vol. 10, pp. 5-10, Jan. 28, 1899.)

Washington, H. S.

The petrographical province of Essex county, Mass. I. (Jour. Geol., vol. 6, pp. 787-808, Nov.-Dec. 1898.); II. (Jour. Geol., vol. 7, pp. 53-64, Jan.-Feb. 1899.)

[White, C. A.]

Supplement to the annotated catalogue of the published writings of Charles Abiathar White. By T. W. Stanton. (Proc. U. S. Nat. Museum, vol. 20, pp. 627-642, 1898.)

Williston, S. W.

The red-beds of Kansas. (Science, new ser., vol. 9, p. 221, Feb. 10, 1899.)

Winchell, N. H.

Chlorastrolite and zonochlorite from Isle Royale. (Am. Geol., vol. 23, pp. 116-118, Feb. 1899.)

Woodworth, J. B.

The ice-contact in the classification of glacial deposits. (Am. Geol., vol. 23, pp. 80-86, Feb. 1899.)

Wortman, J. L.

The extinct Camelidæ of North America and some associated forms. (Bull. Am. Mus. Nat. Hist., vol. 10, pp. 93-142, pl. 11, 1898.)

PERSONAL AND SCIENTIFIC NEWS.

PROF. T. C. CHAMBERLIN, head professor of geology at the University of Chicago, is rapidly recovering from his recent illness.

DR. H. FOSTER BAIN, assistant state geologist of Iowa, is delivering a course of lectures on economic geology to the graduate students of the geological department of the University of Chicago. During Dr. Bain's absence from Des Moines Dr. W. S. Beyer, professor of geology and mining at the Iowa State College of Agriculture and Mechanic Arts, has charge of the office of the Iowa geological survey.

IN A SERIES OF TWELVE SATURDAY AFTERNOON LECTURES, which began January 7, some of the curators and assistant curators in the American Museum of Natural History have been giving the public illustrated accounts of recent work carried on by the institution. Among these lectures have been two bearing on geology, one February 18 by Mr. L. P. Gratacap on "The rocks of the State of New York, as illustrated in the Museum," and the other February 25 by Dr. E. O. Hovey on "A geological collecting trip in Russia."

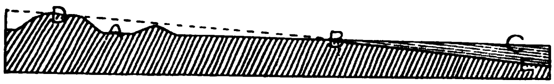
PROF. W. M. DAVIS, who has been spending the winter in France, has just returned to Paris from an extended trip among the volcanoes of the central plateau.

ON FEB. 17TH, PROF. H. F. OSBORNE gave a noteworthy lecture before the Boston Society of Natural History, on "The Development of the Mammalia," drawing his deductions chiefly from the fossils of the west.

DR. R. A. DALY, who for this year has taken Prof. Davis' work in Physiography at Harvard University, is completing studies begun in Germany, on the optical properties of amphiboles and pyroxenes, particularly the former; and his first paper on the subject has just appeared, (Amer. Acad. Arts and Sci., proc., vol. 34, pp. 311-323; 1 fig., 3 pls.)

THE COURSE OF SATURDAY EVENING LECTURES at the American Museum of Natural History, New York city, this winter under the auspices of Columbia University, has included four on mineralogy during February. They were, February 4, "The transmission of light in crystals," by Prof. A. J. Moses; February 11, "The characters of minerals in rock sections," by Dr. Lea Mc I. Luquer; February 18, "The methods employed in the investigation of minerals, especially their application to the identification of species," by Prof. S. L. Penfield; February 25, "Testing minerals," by Prof. A. J. Moses.

THE WEST VIRGINIA GEOLOGICAL AND ECONOMIC SURVEY has this year issued a map of that state compiled by Mr. R. L. Morris under the direction of the state geologist, Dr. I. C. White. The geological features represented on this map are oil pools, natural gas wells, New River coal areas, Alleghany or Kanawha River coal areas, and Pittsburg coal areas. Dr. White states that this map is a preliminary one and that the information presented is, in part, only approximately correct, but that, if the survey should receive proper financial support, it is his intention to publish accurate and detailed maps of the coal, petroleum, and natural gas areas.



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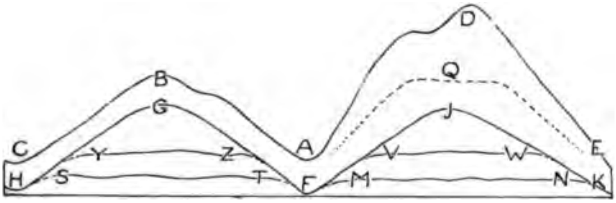

FIGURE 2.

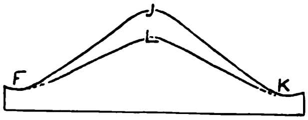

FIGURE 3.

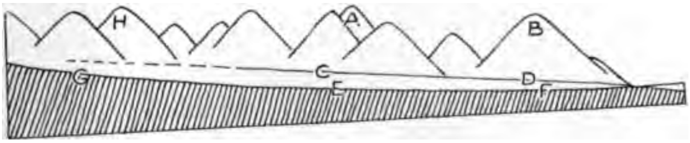

FIGURE 4.

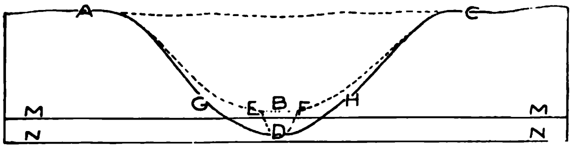

FIGURE 5.

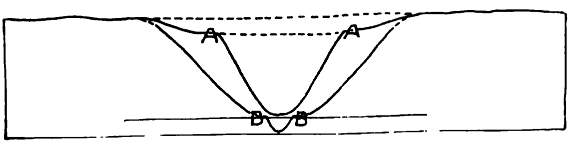

FIGURE 6.

THE

AMERICAN GEOLOGIST.

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THE PENEPLAIN.

By W. M. DAVIS, Cambridge, Mass.

[Plate VII.]

Had it not been for the distractions of foreign travel during a year of absence from college duties, I should have sooner written a reply to Professor Tarr's article on "The Peneplain" that appeared in the Geologist for June, 1898. The delay has not, however, been a disadvantage on my part, for it has enabled me to talk over the problem with a number of English and French geologists and geographers who are interested in such matters, and thus to free my reply somewhat from individual prejudices. The discussion that Professor Tarr's article should awaken will be a welcome one, for as he has well said, the peneplain is too important a matter to gain an accepted position without close scrutiny. The courteous and earnest tone of Professor Tarr's essay will, I hope, determine the style of those that follow it.

At the outset, allow me to correct the implication that the "peneplain idea" was original with me. The name is of my invention, and, as has sometimes happened, the introduction of a definite name for a thing previously talked about only in general terms has promoted its consideration:—witness the name, antecedent, for rivers that hold their courses against mountains uplifted beneath them. The idea of antecedent rivers had occurred to several observers who gave it no name, and unnamed it gained no general currency; but it became popular when Powell named it. Moreover, the ideas of antecedence and peneplanation were ripe in many minds about the time the names were suggested, and it is chiefly for that

reason, as it seems to me, that antecedent rivers have been so frequently mentioned in the last thirty years, and peneplains in the last ten.

It was in Powell's "Exploration of the Colorado River" (1875) that the "peneplain idea," along with a number of other important facts and principles, first came to my notice. The idea is not stated categorically, but when describing the even surface of deformed rocks beneath the horizontal Carboniferous strata in the Colorado canyon, Powell said that "aerial forces carried away 10,000 feet of rocks by a process slow yet unrelenting, until the sea again rolled over the land," and the evenly denuded surface is referred to as "the record of a long time when the region was dry land" (p.212). In a later work, the same author writes:—"Mountains cannot long remain as mountains; they are ephemeral topographic forms. Geologically speaking, all existing mountains are recent; the ancient mountains are gone" (Geology of the Uinta Mountains, 1876, 196). Again, "in a very low degree of declivity approaching horizontality, the power of transporting material is also very small. The degradation of the last few inches of a broad area of land above the level of the sea would require a longer time than all the thousands of feet which might have been above it, so far as this degradation depends on mechanical process—that is, driving or flotation; but here the disintegration by solution and the transportation of material by the agency of fluidity come in to assist the slow processes of mechanical degradation, and finally perform the chief part of the task" (Ibid., 196). Dutton referred to Powell's having given precision to the idea of baselevel, an idea probably known previously in a general way to many geologists. "All regions"—Dutton says—"are tending to baselevels of erosion, and if the time be long enough each region will, in its turn, approach nearer and nearer, and at last sensibly reach it" (U. S. G. S. Monogr. II, 76).* In Great Britain, where the litera-

*I had expected to find some similar sentences in Gilbert's "Geology of the Henry Mountains," but discover instead the following statement:—"It is evident that if steep slopes are worn more rapidly than gentle, the tendency is to abolish all differences of slope and produce uniformity. The law of uniformity of slope thus opposes diversity of topography, and if not complemented by other laws, would reduce all drainage basins to plains. But in reality it is never free to work out its full results; for it demands a uniformity of conditions which nowhere exists" (p. 115).

ture very generally indicates a belief in plains of marine abrasion, a number of geologists have, without public announcement in any formal manner, gradually enlarged the share of work attributed to subaerial forces, until, as some of them have lately assured me, the "peneplain idea" has come to be for a number of years as familiar to them as to most American geologists; and some of them certainly entertained it before the term, peneplain, was suggested. Several examples of the recognition of the "peneplain idea" by continental geologists might be given if time and space permitted, but I will here refer only to the essay by Penck, quoted below (B 4).

Professor Tarr argues, in effect, that certain regions instanced as dissected peneplains have never really been lowlands of faint relief; that the process of peneplanation is in itself an extremely unlikely one; and that the so-called peneplains, all of which are now more or less dissected, are capable of other explanation; in brief, that peneplains are (A) unreal, (B) improbable, and (C) unnecessary. Several subdivisions of each of these headings will be made in replying to them. Page numbers refer to Professor Tarr's original article.

A 1. *Certain regions show no trace of peneplanation.* It is stated that "one standing upon the crest of one of the mountains of central Maine would hardly find the evenness [of the sky line] sufficient to give the appearance of levelness even to the eye" (p. 357). But no one, so far as I know, has thought that the mountain tops of Maine mark the remnants of a peneplain. The mountains there are probably of the nature of monadnocks; it is only the general upland surface above which the mountains rise that can be regarded as a peneplain, uplifted and dissected, if the features that I have seen about Portland and at some other points along the coast may be extended inland. The White mountains have been, in my mind, tentatively classed as a group of monadnocks; they do not, as far as I have seen them in brief excursions, stand upon any distinct basement comparable to that of the uplands of New England further south; but Mr. Philip Emerson, master of the Cobbett school, Lynn, tells me that he has in summer excursions traced what he thinks may be regarded as the extension of the more southern uplands around

the White mountains on the east, north, and west. Northern New England is not to-day well enough mapped or studied to give either decided support or disproof to the theory of peneplains. Its ruggedness is generally so great that it is quite possible that the peneplain explanation does not apply to the greater part of the area. Little wonder that an observer whose attention is given to this mountainous district, under the impression that its mountain tops represent the remnants of a peneplain, should come to discredit such an explanation.

A 2. *The uplands of southern New England and of northern New Jersey are not of uniform altitude.* It is urged that a careful examination of the topographic maps of these regions disproves the accordance claimed for their upland altitudes. In answer, I should say that the lack of uniformity among the uplands—a fact perfectly familiar to those who accept the peneplain idea—is partly the result of titling, as will be further considered below (see A 4); and that for the rest the unevenness of the uplands of to-day is a natural result of imperfect peneplanation followed by submature dissection. The examination of the peneplain remnants by means of topographic maps is not a new method of investigation, as it was employed for New Jersey in 1888-89, and for southern New England a few years later; but, like observation out doors, it seems to lead different investigators to different results. Considerable as the inequalities of altitude are, frequent study of the maps and repeated views of the uplands from various hill tops impress me much more with the relative accordance of their altitudes than with their diversity. I cannot admit that the appearance of accordance from hill top to hill top is an optical deception. There is an important matter of fact behind the appearance.

The comparative evenness of the uplands in Connecticut was recognized and well described by Percival over half a century ago. The state being divided into eastern and western areas of primary rocks by the trough of Triassic strata, he said:—"the eastern and western primary may both be regarded as extensive plateaus, usually terminating abruptly toward the larger secondary basin, but sinking more gradually toward the south, on the sound. These plateaus present, when viewed from an elevated point on their surface, the appear-

ance of a general level, with a rolling or undulating outline, over which the view often extends to a very great distance, interrupted only by isolated summits or ridges, usually of small extent. These plateaus are also intersected by valleys and basins, which serve to mark the arrangement of their surface even more definitely than the elevations. This arrangement will be found to correspond very exactly with that of the geological formation, indicating that it was caused essentially by the original form of the surface of these formations, and not by any subsequent denudation" (Geol. Conn., 1842, 477). "The western primary . . . forms, within the limits of this state, a wide plateau . . . of so uniform an elevation that from many points, the view extends across its entire width, and to a great distance north and south" (Ibid., 478.) "The eastern primary, viewed from its more elevated points, presents the same general appearance as the western; that of an extensive undulating surface of nearly uniform elevation, diversified by detached summits" (Ibid., 482). The peculiar conclusion of the first of the above quotations is interesting in contrast to modern views.

In eastern Massachusetts, dissection has gone so far that it would be difficult to discover an uplifted peneplain on local evidence alone; but in the central and western parts of the state, the uplands are generally so well defined and so accordant that I am at loss to understand why Professor Tarr should say:—"While near the coast there is a certain semblance of levelness, I am utterly unable to find even the appearance of uniformity in the more elevated sections of New England" (p. 358). Looking eastward from the Berkshire hills across the Connecticut valley lowlands in northern Massachusetts, the skyline of the central plateau is to my eyes astonishingly uniform, though its altitude is over 1,000 feet. Hence it must be agreed that with the same facts before us, both out doors and on maps, our descriptions and interpretations of them do not correspond; one of us being impressed with the diversity of the upland altitudes, and the other with their accordance.

A 3. *The remains of certain peneplains are fragmentary.* It is urged that ten per cent of the original area of the supposed peneplain, now preserved in the uplands of Connecticut, is too small a fraction to serve as a basis of reconstruction.

This does not strike me as a serious or a novel difficulty. Geologists are often compelled to work on fragmentary evidence; they are satisfied if the fragments can be logically built up into the complete structure. In most parts of the world, rock outcrops occupy less than ten per cent—often less than one per cent—of the land surface; yet no field geologist hesitates to "color in" a formation over an area where scattered outcrops give reasonable proof of its occurrence. The surface area thus colored in is often but a small part of the entire body of the original formation, which may be largely covered by later deposits or destroyed by erosion; but the covered and eroded portions are reasonably inferred, and a formation thus established is a stock subject in historical geology. It is therefore not so much a high percentage of direct observation, as a logical method of reconstructing the unseen whole from the observed parts that is necessary. Here the dissected peneplain seems to me to stand on a par with many other things. Its fragmental condition is most natural; its discovered parts are connected and the lost peneplain is restored by a line of argument that is perfectly reasonable in itself, and that is objected to only because it runs counter to certain views that are held by Professor Tarr to be established principles in the science of geology. These views will be considered below (B 1, 2).

A 4. *Certain so-called peneplains are now inclined.* Professor Tarr says:—Uplift or tilting "is an assumption rendered necessary to explain the difference in elevation of the supposed peneplain; but I fail to find that there is any evidence to prove it, unless the peneplain be previously accepted as a condition covering this entire region" (p. 358). Here we fully agree. I have repeatedly insisted that it was only by recognizing the existence of a peneplain that uplift or deformation could be determined in certain cases; and that only in this way could certain stages of geological history be discovered, in the absence of what might be called orthodox geological evidence in the form of marine deposits. For example, it is by the remnants of an uplifted, inclined, and warped peneplain in the even crest lines of the Pennsylvania Appalachians that the post-Cretaceous uplift of the mountain belt has been determined; it was formerly supposed that

the existing ridges were the unconsumed remnants of the ancient Appalachians, and by implication, that no uplift of the region had occurred since the mountains were crushed, folded, and upheaved. So in southern New England: there was no means of determining the date of uplift, as a result of which the existing valleys were eroded, until the peneplain of the uplands was recognized and dated. Twenty or thirty years ago, it was not uncommon to meet the suggestion that the valleys might be of glacial origin, so little understanding had then been reached of the geographical development of the region. Those who believe in the verity of peneplains will infer uplift, where they see a high-standing and dissected peneplain, as confidently as the geologists of the end of the eighteenth century inferred uplift when they found marine fossils in stratified rocks far above sea level.

But it does not seem warranted to conclude that the peneplain theory is invalidated because certain peneplains are now uplifted on a slant, although this is implied in Professor Tarr's argument (p. 359). It is no objection to the peneplain idea to say that the crest of Kittatinny mountain is higher than the upland surface of the New Jersey highlands (p. 356), or that the crest of the palisades is lower. It would be as extraordinary to find no slanting peneplains as to find no inclined strata. Warped and faulted peneplains are no more unlikely products of crustal deformation than warped and faulted sedimentary formations; witness the dislocations of the plateaus trenched by the Colorado canyon, the plateau surface having been worn down to "a very flat expanse" before the uplift and displacements that have determined the altitudes and forms of to-day.

A 5. *Objections based on the fragmentary condition of certain peneplains further considered.* If the best preserved peneplains were not less fragmentary than the ones that Professor Tarr has discussed quantitatively, the theory of peneplains might perhaps be overthrown: but when the imperfect peneplains of New England and New Jersey are considered in connection with many more nearly perfect peneplains elsewhere, the series becomes so well graded, from better to worse, that the theory seems to me unassailable. A few examples of the better preserved peneplains may therefore be now considered.

The Piedmont belt of Virginia has been described by a number of observers in recent years. McGee writes:—"The plain is not monotonously smooth; here it undulates in graceful swells, there it dips into rocky river gorges, winding across its width. . . . Such is the Piedmont plain within view of Monticello and such is the province throughout its extent from New York to Alabama" (Nat. Geogr. Mag., viii, 1896, 261). The Piedmont rivers "rush through narrow, rock-bound gorges. . . . All the Piedmont rivers, large and small, are incessantly corrading their beds" (Ibid., 262). The plain "must be regarded as the basal portion of a vast mass of inclined rocks of which an unmeasured upper portion has been planed away" (Ibid., 263). In describing the same region, Darton writes:—"The Piedmont plateau is a peneplain of Tertiary age . . . the plain has been deeply trenched by drainage ways, but wide areas are preserved on the divides" (Chicago Journ. of Geol., ii, 1894, 570). He believes that this peneplain, AB, fig. 1, continues across the inner strata, BC, of the coastalplain, and that it should therefore be distinguished from an earlier peneplain carved on the same ancient rocks, part of which is BE, preserved beneath the strata of the coastal plain, and part of which, DB, is generally hereabout destroyed by erosion. It is upon the older peneplain that the Potomac formation, with its fossil terrestrial flora, directly rests. Keith gives an elaborate account of a part of the Piedmont plain in his "Geology of the Catoctin Belt" (14th Ann. Rep. U. S. G. S.), and discusses its relations to various members of the coastal plain series.

Any one who will follow up the foregoing references, or who will, better still, look over the region on the ground, will find a decidedly larger portion of the peneplain surface preserved than is the case in New England or New Jersey: and this is most natural, for the Virginia Piedmont plain is of distinctly later origin than the peneplain of the uplands further north: the latter corresponds to the earlier peneplain, DBE, in Virginia. But it is not only the comparative continuity of the Piedmont plain that makes it a valuable example: the deep soils of the upland plain and the rocky walls of the narrow steep-sided valleys are as important witnesses to the once lower position of the plain and to the uplift by

which its present altitude has been gained as are the forms of the upland and the valleys. To explain this point more fully, a brief digression may be allowed.

The peneplain is only one element in the theory of the geographical cycle.' The systematic sequence in the development of land forms through the cycle is a much larger and more important principle than the penultimate development of a peneplain, considered alone; for the former includes the latter. One of the elements of the cycle is the development of the graded condition of streams of water during maturity, whereby an essential agreement is brought about between the ability of a stream to do work, and the work that it has to do. Another element, less generally recognized, is the development of the graded condition in the streams and sheets of rock waste or soil on sloping surfaces, where no running streams of water occur. By following out the ideal scheme thus suggested, it must result that just as the graded condition of water streams is normally propagated from the mouth towards the head, and in time reaches the source of all the branches, so the graded condition of soil-covered slopes is in time extended all over a land surface, from the valley floors to the divides. The supply of waste by the disintegration of the sub-soil rock is then everywhere essentially equal to its removal by all available agents of transportation. In a late stage of a cycle, when the surface slopes are small, agents of transportation are weak; hence the supply of waste must then be slow and the waste to be removed must be of fine texture. In order that the supply shall be slow, the waste comes to have a great depth,* and the upper parts greatly protect the rock beneath from the attack of the weather. At the same time,

*It is not at first sight clear why the depth of soil should increase on a graded waste slope, if the supply and removal of rock waste are (essentially) equal. As a matter of fact, the supply exceeds the removal by a quantity of the second order. Then as the slope decreases and the agencies of removal weaken, the depth of soil increases by just such a measure as will suffice to reduce the agencies of weathering (supply) to equality with the waning agencies of transportation (removal). This is only one of the many natural examples of an (essential) equilibrium, maintained between varying forces and resistances. In elementary presentation, when the condition of a graded waste slope at a given stage of development is considered, and attention is not directed to the variation of the forces and the resistances with the advance of the cycle, the equilibrium may be announced without qualification: in more advanced presentation, the hedge-word, essential, is an assistance to clear understanding.

transportation is facilitated by the refinement of the surface soil during its long exposure to the weather. Hence, under ordinary climatic conditions, normal peneplains must have deep local soils of fine texture at the surface, and grading into firm rock at a depth of 30, 50, or more feet. Moreover, it is only on a lowland surface of small slope that such a depth and arrangement of local soil can be normally produced.

In contrast to the deep soil of a peneplain, the steep sides of young valleys, whose graded waste sheets are not yet developed, must frequently reveal bare, rocky ledges. Only as the valleys widen and their side slopes become somewhat more gentle, will the ledges disappear; and even then the rock will be covered only by a relatively thin and coarse sheet of rapidly creeping waste. It therefore follows that the uplands of the Piedmont belt, with their deep soil, are of an essentially different cycle of development from the narrow valleys, with their bare ledges. The two elements of form remain mutually inconsistent, until reconciled by the postulate of an uplift of the region between their developments. But if this postulate is accepted, the plain is shown to have been a lowland of faint relief before the existing narrow valleys were cut in it. It is this double line of argument, based on deep soil and bare ledge, as well as undulating plain and narrow valley, that has convinced various observers of the verity of the peneplain in the Piedmont belt.

The Great Plains of eastern Montana include an area of nearly horizontal Cretaceous strata on either side of the Missouri river, regarding which the evidence of peneplanation seems to me beyond dispute. Here and there, volcanic buttes, dikes, and mesas surmount the plain by several hundred feet; on the south, the Highwood mountains, a network of dikes among nearly horizontal shales and sandstones, rise in still stronger relief. Hence there can be no question that strata, measuring hundreds if not thousands of feet in thickness, have been broadly removed from the region by denudation. Yet the surface between the various eminences that rise above it is a true geographical plain. It is not absolutely level, but broadly undulating, with a sky line almost as even as that of the ocean itself. In this plain, the Missouri river and its chief branches have cut narrow, steep-sided valleys, several hun-

dred feet below the general upland level. These valleys are so young that the Missouri itself has not yet developed an even slope; witness its several leaps at Great Falls. Innumerable wet-weather side-streams are cutting sharp ravines in the larger valley sides. It does not seem possible to avoid concluding that the upland plain is to-day in process of destruction by an agency that could not have been in operation while the finishing touches were given to its production. It was upon this peneplain in 1883 that the necessity of believing in penultimate denudation was first strongly impressed upon me. Dr. Waldemar Lindgren, now of the U. S. Geological Survey, who was with me in the field, may recall how the conviction grew upon our minds; if I am not mistaken, he accepted it before I did. A brief account of the region is published in volume XV of the Tenth U. S. Census Reports.

The extended plains of Central Russia, as lately described by Philippson (Zeitschr. Ges. f. Erdk. Berlin, xxxiii, 1898, 37-68, 77-110), have a gently undulating surface at a height of 200 or 300 meters, broadly continuous, but here and there dissected by relatively narrow, steep-sided, young valleys. The upland surface is not a structural plain, for it bevels across formations of very different ages: it is therefore a plain of erosion. In the south, there is a partial covering of loess, a thin veneer often absent and leaving the rock surface visible over large areas. In the north, the drift cover is heavier and more continuous; but the plateau surface is still the continuation of the same plain of erosion as in the south. There is no record of marine action on the great plain, hence its erosion is ascribed to the lateral swinging of the lower courses of large rivers, but the origin of the rivers is unknown: it can only be said that when the erosion was going on, the Russian "Scholle" must have stood 200 meters lower than to-day. The narrow valleys have been cut since the uplift of the plain and are older than the glacial period (see especially p. 38-42, 54, 55, 62, of the above-cited essay). This is the largest peneplain of which I have found any account.

A 6. *The asserted discordance of peneplain surface and rock structure is open to question.* It is said to be questionable "whether there is after all such a lack of sympathy between topography and rock structure" as has been repre-

sented (p. 359), and in evidence of this doubt it is said that in the Highlands of New Jersey there is "a very evident general sympathy between the present topography and the rock texture" (p. 360). There is some danger that our discussion may here run into cross purposes, for this objection to peneplanation does not meet the arguments advanced in its favor. Disregarding the weaker structures, which are now worn down beneath the inferred surface of the peneplain, it seems to me undeniable that the peneplain surface was strongly discordant with the hard structures that still preserve its remnants. It is a matter of necessity that the present topography of an uplifted and dissected peneplain should exhibit sympathy between form and structure, for where should better accordance of form and structure be expected than in such a region of adjusted drainage; but this is a matter quite apart from the present discussion.

Various gneisses, sandstones, and trap sheets, standing in a more or less inclined position, are truncated with good appearance of system by the gently slanting surface of the peneplain of northern New Jersey. The following description of the region is taken from one of Cook's reports. "The Highland mountain range consists of many ridges which are in part separated by deep valleys and in part coalesce, forming plateaus or table-lands of small extent. . . . A characteristic feature is the absence of what might be called Alpine structure [form?] or scenery. There are no prominent peaks or cones. The ridges are even-topped for long distances and the average elevation is uniform over wide areas. Looking at the crests alone and imagining the valleys and depressions filled, the surface would approximate to a plane gently inclined toward the southeast and toward the southwest" (Geol. Surv. N. J., Ann. Rep. 1883, 27. See also p. 28, 29, 60, 61). It is this indifference of the peneplain to the various structures that it systematically truncates that has always been the chief argument of those who thought they saw traces of a former lowland where there is to-day a dissected highland, whether they believed in marine abrasion or in subaerial denudation.

Special mention may be made here of certain features that will be referred to more briefly in a later section (C 4). Descending the Hudson from Haverstraw to Jersey City, one

may see a gradual decrease of altitude in the palisades, a ridge formed on a monoclinal sheet of dense intrusive trap, from a hight of about 600 feet in the north, to sea level in the south. There is no corresponding variation in the thickness of the trap sheet. The uplands of schists and gneisses on the east of the Hudson have a similar descent from the Highlands to Long Island sound. In Connecticut, the view from East Rock, New Haven, discloses the extraordinarily even crest line of Totoket mountain, the edge of a strongly warped sheet of extrusive trap. The crest line slowly descends southward and is continued by the somewhat lower crest line of Pond mountain, of similar structure. Furthermore, the descent of these crest lines agrees very well with the descent of the crystalline uplands next on the east. The systematic relation of these and many other crest lines and uplands suggests a peneplain, and the peneplain thus inferred is strikingly indifferent to the structures that it truncates. It might be urged that the observed discordance of form and structure is of some other origin than peneplanation; but the discordance does not seem open to question.

A 7. *The rocks of monadnocks are not proved to be more resistant than those of the adjoining peneplain.* It is urged that there is no other proof of the durability of the rocks of monadnocks other "than that which comes from the necessity of such an explanation, made necessary by first accepting the existence of the peneplain" (p. 358). As far as my own work is concerned, there is some ground for this objection. I have as a rule given no particular attention to the composition of the monadnock rocks; indeed, it has generally seemed to me reasonable to infer their greater resistance on account of their form. But so far as attention has been given directly to this phase of the problem, the inference based on the peneplain theory is borne out by petrographic study. The buttes and mesas that surmount the plains of the upper Missouri are maintained by dense igneous rocks. The monadnocks of the Virginia piedmont belt "are ribbed with siliceous schists or quartzites or other rocks that resist well the work of the weather . . . while the rocks underlying the fertile fields of the plain are softer schists, easily weathered and worn away" (McGee, l. c., 262, 263). Near Atlanta, Ga., the Piedmont area is a well

finished peneplain, rather strongly dissected, with deep soils overlying the uplands of gneiss and schist. Stone mountain, a superb monadnock of abrupt form, consists of fine homogeneous granite, quite unlike the rocks of the peneplain (Purington, Amer. Geol., xiv, 1894, 105-108). Van Hise, in describing the uplands of the ancient disordered and indurated rocks in north-central Wisconsin, says that they constitute "as nearly perfect a baselevel plain as it has been my good fortune to see. * * * Above the valley of the Wisconsin river, an almost perfect plain is seen * * * large areas of which are but little dissected by any of the tributary streams of the Wisconsin." The upland plain is surmounted by Big Rib hill, a monadnock of exceedingly resistant quartzyte (Science, N. S., iv, 1896, 57-59). The upland of the Slate mountains in western Germany is a wonderfully fine peneplain of broad and gentle undulations, now undergoing active dissection by the branches of the Rhine, Mosel, and other strong rivers which have eroded their steep-sided valleys deep beneath its even surface. The upland is surmounted by several ridges or elongated monadnocks; and some of these at least are composed of a very resistant quartzyte. In New England, the type Monadnock is, if my memory serves me, largely composed of an andalusite schist, which certainly has every appearance of being a resistant rock. Yet it must be freely admitted that, as far as I know, no artificial test has been made of its resistance as compared with that of many apparently resistant rocks around its base. It may be added that an appropriate test would be difficult to devise, inasmuch as exposure for ages to the weather would certainly be the best means of discovering the way in which long ages of weathering will affect a rock. In view of this difficulty, I hope that those who regard the peneplain explanation as compulsory will not be left alone to devise appropriate tests to determine the resistance of monadnock rocks, but that Professor Tarr and any others who are interested in the development of land forms, but who feel no such compulsion from the peneplain theory, will nevertheless turn their ingenuity in this direction. It is the truth of the matter that we are all striving for, not the maintenance of this theory or that; and it seems unfriendly if not unscientific to say that "the burden of proof should rest with the advo-

cates of the explanation." I am no more willing to be considered an advocate than I suppose Professor Tarr is to be thought an enemy of peneplanation. We are not retained to argue for or against the theory; each of us follows the guidance of the best evidence he can find. I trust that Professor Tarr is just as much interested to discover whether monadnock rocks are resistant as I am to discover whether his theory will account for uplands with even skylines. It is of course difficult to avoid the appearance and even the style of the advocate or the enemy when writing earnestly in expression of one's convictions, but for my part I cannot say too emphatically that the peneplain idea shall find no "defense" from me. Let us all set forth the *pros* and *cons* to the best of our ability, and then the peneplain idea must look out for itself, and stand or fall according to its value.

The objections thus far discussed relate to actual examples of supposed peneplains. Attention may be next turned to a group of objections based on general considerations, leading to the belief that the production or occurrence of peneplains is improbable or even impossible.

B. I. *No peneplains are now found standing close to base-level.* It is stated that "no extensive peneplains [not uplifted or dissected] are known to exist at the present time in any part of the earth," although "peneplains have been produced again and again in the past. * * * Therefore, in accepting the peneplain theory, we need, as a fundamental assumption, to believe that during a part of the remote past, the conditions have been different from these that have prevailed in any part of the known earth during the present and immediate past" (p. 353, 354). Here Professor Tarr and I are in essential accord, although I should prefer to replace "fundamental assumption" by "necessary corollary." As far as my own understanding of the problem is concerned, it was not at all as a fundamental assumption, but as a very surprising corollary that I came upon the difference between the present and certain parts of the past, with respect to peneplanation. This aspect of the question has often been discussed with my advanced classes, but it has not yet received the attention that it deserves, and I am obliged to Professor Tarr for bringing it clearly forward.

Although agreeing in the belief that the theory of peneplains involves a certain difference between the past and the present, we do not agree as to the bearing of this belief on the theory. Professor Tarr implies that the past, "whose history has been worked out by purely stratigraphic methods," is proved to be so like the present that the theory of peneplains must be wrong because it involves a past that is in some ways unlike the present. My opinion is that stratigraphic methods do not always disclose a past closely like the present (see B4): and that, even at their best, stratigraphic methods are not so complete in their revelations but that all other lines of evidence concerning the nature of the past should have a careful hearing.

There are certain parts of the world in which frequent disorderly movements of the earth's crust appear to have continued during several geological periods, including the present; for example, the Alps. The teachings of Mesozoic and Cenozoic stratigraphy in such a region would lend no support to the theory of peneplanation; as little support would be gained from the teachings of denudation in the Alps. Indeed, I have been interested to learn that certain careful students of geomorphy in the neighborhood of the Alps have recognized that they were prejudiced against the theory because their experience was gained chiefly in an uneasy part of the world. But there are other parts of the world which have been relatively quiescent for long geological periods: for example, the upper Mississippi basin, where all represented formations from the Cambrian down, are essentially horizontal and of moderate thickness. Stratigraphy, as there taught, would not be inconsistent with peneplanation: neither would geomorphy, and to illustrate this I have a little story to tell. During an excursion with a friend native to that part of the country, I pointed out the very even skyline of a dissected upland, as an example of a peneplain. My friend dissented, thinking no such special explanation necessary: ordinary denudation would suffice, he thought, to produce the observed forms, without specification of control by different baselevels. A year later, on meeting the same friend, our talk happened to turn on peneplains, and he said: "I should like to show you an excellent example of that sort of thing," proceeding to describe

the very region we had seen together. "How," I asked, "did you come upon that explanation?" "I cannot say precisely how," he replied; "it is nothing new." This incident seems to me to illustrate the unconscious encouragement given to the idea of peneplanation by a quiescent environment, in contrast to the discouragement given in such a region as the Alps.

Unrest and quiescence are not persistent characteristics of one region or another. Pre-Cambrian time was active enough in the Wisconsin-Minnesota region; and there are indications of relative quiet in the Alpine region before its Mesozoic and Cenozoic activity began. But this aspect of the problem is too large for consideration here. Suffice it to say that there is yet much to be learned about the past, and that I fully agree with McGee in believing that the world's history is to be read in denudation as well as in deposition. If the deciphering of trustworthy records of denudation leads to the conclusion that the present is in some respects exceptional, a peculiar chapter in the earth's history, then I should have to add that conclusion to the other authenticated conclusion which go to making up the history of the planet. Admitting the present to be exceptional in the lack of peneplains close to their baselevel of production, and thus postulating general disturbances by uplift and tilting in the recent past, I doubt if this condition is more exceptional than that which permitted the widespread deposition of the chalk of Europe upon its even foundation, or than that which determined the formation of the Coal Measures of Europe and North America. There does not seem to be any severe strain upon the reasonably elastic form of the doctrine of uniformitarianism in meeting the requirements of the peneplain theory.

B 2. *The earth's crust will not stand still long enough for the slow process of denudation to produce a peneplain.* It is justly urged that according to theory the later stages of peneplanation are much longer than the early stages of dissection (p. 354), as Powell clearly pointed out some years ago; and it is inferred that the earth's crust will not stand still long enough for even penultimate denudation to be accomplished (p. 362). But the stability or instability of the earth's crust can be learned only by comparing the consequences reasonably deduced from one condition or the other with observed facts.

It seems to me a prejudgment of the case to enter it with the conclusion that the lands do not stand still long enough for peneplanation. Certainly they do not stand still long enough in certain regions; witness the manifest effects of uneasiness in the varied and unconformable stratified deposits, or in the repeated renewals of dissection in the Alps. But the opposite conclusion is enforced by both lines of evidence in the Piedmont region of Virginia.

Another example may be taken from the West. The upland of the plateaus trenched by the Colorado canyon is by no means a level surface; but if the fault cliffs and the monoclinal slopes by which it is dislocated, the canyons by which it is dissected, and the volcanic cones by which it is embossed were subtracted, the remaining relief could not, if one may judge by Dutton's vivid descriptions, be so great but what the surface might be called a peneplain, especially if due regard is had to the vast volume of material removed in its preparation, as attested by the huge cliffs of recession on the north. It is true that a certain part of the upland seems to be a structural plain; that is, its surface agrees rather closely with that of the more resistant Carboniferous layers; but when looked at broadly, the upland is seen to bevel gently across the edges of the layers, which dip northward at a faint angle. In explanation of this great denuded upland, Dutton says that the evidence points decisively to a "period of quiescence" in Tertiary time; "while it prevailed, the great Carboniferous platform was denuded of most of its inequalities, and was planed down to a very flat expanse" (Monogr. II, U. S. G. S., p. 77). The supposition of a period of active uplift, during which the incision of valleys was begun, and a period of quiescence, during which the hills were worn away, "would give just such a country as we see at present" (Ibid., 225). Inasmuch as the platform is now in process of active destruction by the widening of the main and branch canyons, a strong uplift must be postulated after the period of quiescence during which the platform was denuded. In all this inquiry, the argument based on processes of denudation is fully as logical and as legitimate as the argument elsewhere based on the processes of deposition.

But it has never been my intention to imply an absolute still-stand of the earth's crust during an entire cycle of denuda-

tion. Any sort of movement that does not cause a distinct dissection of the surface below the peneplain level is admissible. Well-preserved peneplains, now dissected only by young, narrow valleys, give assurance that no significant valley-cutting below the peneplain level was permitted before the uplift by which the erosion of the existing valleys was initiated. Even in so uneven a region as southern New England, the gradual decrease of relief on approaching the coast makes it extremely probable that the deep valleys of the interior were not cut till after the peneplain was essentially finished. Any other supposition involves special conditions of oscillation and tilting that I believe are less probable than those involved in peneplanation, as may be seen by drawing a series of diagrams to represent the successive attitudes assumed by the land under different hypotheses.

It is sometimes suggested that before peneplanation, but after valleys like those of southern New England had been excavated, economy of work and time would be served by postulating a depression and a truncation of so much of the mountains as then remained above baselevel. The truncated surface thus produced would, under this supposition, correspond to the New England uplands. This truly effects an economy of work, measured by area of baselevelling, but it effects no important economy of time; for it will require essentially as long a time to truncate or baselevel a large cone as a small cone, structure and slope being equal. Moreover, unless very special suppositions were made as to the attitude of the land before, during, and after such a truncation of its mountains, the existing forms of southern New England could not be explained. During a submergence long enough to truncate the mountains remaining above baselevel, many shallow valleys would be filled with marine deposits; and after elevation, the streams might frequently abandon their former valleys for new, superposed courses. The narrow new valleys excavated on such courses, and the former valleys in which remnants of marine deposits might long linger, are not represented in southern New England.

Yet any supposition or process that will aid in the destruction of a land mass must be welcomed by those who believe that land masses have been destroyed, close down to baselevel.

The lateral swinging of large rivers, occasional incursions of the sea, changes of climate, anything that will contribute to the end is a pertinent part of the theory of peneplanation. Still my own opinion is that, of all processes, subærial denudation is the most important. This is not simply an opinion of preference; it is an opinion based on the arrangement of rivers in uplifted and dissected peneplains (Bull. Geol. Soc. Amer., vii, 1896, 377-398). Such rivers frequently exhibit adjustments that they could not have gained from a disordered arrangement during the present cycle of denudation alone: adjustments that could have been gained for the most part only during the cycle of peneplanation, and that would have been lost if the rivers had wandered far, or if the sea had abraded much of the land during the later stages of that cycle. It is of course perfectly possible that a peneplain should be smoothed off by the sea after it had been worn down under the air: such appears to have been the case with the Cambro-Silurian plain of northwest England (see B3). But it is not reasonable to suppose that every uplifted and dissected peneplain was thus smoothed before it was uplifted, although this supposition finds much favor with certain English geologists.

As to the arguments based on the slow progress of denudation during a brief period of observation (p. 355)or during post-glacial time (p. 361), I can only reply that a geographical cycle must be so enormously longer than either of these intervals that their evidence is not of value. Truly denudation is retarded when a capping of waste protects the rocks from the attack of the weather, but rather than side with De Luc, who concluded that waste-covered mountains are practically protected from further change, I should prefer to side with Hutton, who maintained that even the slow denudation of waste-covered slopes could produce great changes of form. As to the time that has elapsed during the denudation or dissection of peneplains, there is apparently no way of measuring it but by the work done. Hence the question returns to the verity of the peneplains: whether much or little time is needed to produce them is a secondary matter. Above all, a preconception as to the insufficience of geological time should not in this day be urged (p. 361) as a reason for not believing in the possibility of peneplanation. One sometimes hears a student say:

"I should think that drumlin ought to be more eroded if it has stood there unprotected since the ice sheet disappeared." Evidently such an opinion is based on a preconception of too long a post-glacial interval; for how can the interval be measured except by what has happened to the drumlin during its passage! How can past time be estimated except by studying what has happened during the progress of its ages!

B 3. *No part of the earth reveals even an approximation to a peneplain.* It is contended that as all the reputed peneplains now known are of the past, and that as all are now more or less fragmentary, "no part of the earth reveals even an approximation to this supposed condition" (p. 355). This seems to me an over strong statement in view of the form of such districts as the Piedmont belt, above referred to; but leaving aside even the best examples of well-finished and slightly dissected peneplains, let us consider some examples of peneplains that were submerged and unconformably buried after their surface had been reduced to faint relief, and that are now more or less visible where valleys are cut into the compound mass in consequence of uplift. It is true that these peneplains are not today standing in the position in which they were formed, that they make a very small part of the earth's actual surface, and that they are imperfectly open to observation; but it seems to me that they give strong evidence of the verity of peneplains, and that they certainly suffice to set against the strong assertion quoted at the opening of this paragraph.

An excellent example of a plain of denudation is exposed in section on the walls of the Colorado canyon. It is well shown—to those who cannot see the canyon itself—in several photographs by Jackson; it is "the record of a long time when the region was dry land," as already quoted from Powell; and it is thus described by Dutton: "The base of the Carboniferous has a contact with unconformable rocks beneath, which was but slightly roughened by hills and ridges. In the Kaibab division of the Grand canyon . . . . we may observe . . . a few bosses of Silurian strata rising higher than the hard quartzitic sandstone which forms the base of the Carboniferous. These are Paleozoic hills, which were buried by the growing mass of sediment. But they are of insignificant mass, rarely exceeding two or three hundred feet in height" (U.S. G.

S., Mongr. II, 209). This magnificent exposure of an unconformity is further referred to as a local illustration of the widespread erosion of a great mass of land, "afterwards submerged." As the canyon has an accidental position with regard to the buried surface, the single section may be taken as a fair sample of a much larger area than is actually exposed.

A buried plain of remarkably even form underlies the heavy Carboniferous limestones of northwestern England. It has been repeatedly described and figured by English geologists. An official report states:—"It is evident that these [Carboniferous] beds were deposited on an uneven floor of the Silurian rocks, for the line dividing the two formations runs sharply up or down 20 or 30 feet in places, while the bedding of the limestone keeps nearly horizontal. In other places . . . . Silurian grit sticks up in a boss, against the west side of which limestone has been laid down in horizontal strata" (Mem. Geol. Surv. Gr. Britain, Geol. of the Country around Ingleborough, 1890, 23). The inequalities of the floor here referred to are very small in comparison to the hights that the Silurian strata must have reached after their great deformation, for the sections represent the contact surface by an essentially even line, parallel to the limestone beds, and so it may be seen on various valley sides; for example in upper Ribblesdale. The actual contacts displayed in certain hillside quarries on Moughton fell are extraordinarily clear; one of them is well reproduced in the frontispiece to Bird's "Geology of Yorkshire." The heavy Silurian flagstones are so evenly truncated that a single layer of limestone stretches smoothly over them for a hundred feet or more across the quarry; the same limestone bluff may be traced for two or three miles around the side of the fell, close above the uppermost outcrops of the flagstones; and the same general division of the Carboniferous formation lies on the denuded surface over tens or scores of miles. As there is no residual soil on the firm rocks of the denuded plain, and as the overlying strata are heavy marine limestones (excepting local deposits of pebbly beds, one or two feet thick), the floor must have been swept and worn by the sea before Carboniferous deposition began. There seems to be no way of determining how much work was thus done by the sea, and how much had been previously done

by subærial agencies; but whatever the proportions, a well finished plain of denudation, hundreds of square miles in area, had taken the place of a vigorous mountain range, before the deposition of the limestones began.

Goodchild has repeatedly referred to this ancient plain of denudation, and to two others of later date in northwest England. He says that when the deformed Cambrian and Silurian rocks "were brought within the destroying action of the waves . . . . the end of it was that the whole surface of the country was shorn off to one general uniform level; depressions and elevations there were, beyond a doubt, just as there are both depths and islands left on a modern plain of denudation; but in the main the surface was tolerably uniform" (Trans. Cumberland and Westmoreland Assoc., xiii, 1888, 92, 93). Many mountain slopes in the Lake district consist of re-exposed areas of this ancient plain, from which the weaker covering strata have been worn off again (Ibid., xiv, 1889, 76). The plain extends, locally, with marvellous evenness of contour, across the edges of quite five miles of strata" in the Lake district alone (Geol. Assoc., London, 1889, 45).

B 4. *Stratigraphic evidence is against the occurrence of peneplains.* It is said that quiescence sufficient for peneplanation requires conditions different from "those of that portion of the past whose history has been worked out by purely stratigraphic methods" (p. 355). Although I am not sure of just what is meant by "purely stratigraphic methods," it seems fair to regard the two examples given in the preceding section as dependent on at least a mixed stratigraphic argument. These examples were, however, associated with marine strata, and hence the subærial origin of the buried plains is not assured, although there can be little doubt as to the actual occurrence of the plains themselves. The following examples are more pertinent to the present discussion, for they point chiefly to the action of subærial denudation in the production of peneplains.

The Central plateau of France is a part of the ancient Hercynian mountain system of post-Carboniferous deformation, that once stretched across west-central Europe. Judging by the strength of its foldings, its altitude may for a time have rivalled that of the Alps of to-day. The mountains were greatly

denuded during secondary time, as is shown by the comparatively even overlaps of Jurassic and Cretaceous strata on the flanks of the central plateau and elsewhere; but of these buried portions no more need be said at present. Continued denudation at last reduced the region of the central area itself to a surface of moderate relief, and it was upon a surface thus prepared that several brackish Tertiary lakes, communicating with the sea on the north and south, laid down their sediments. Since then, the region as a whole has been much uplifted, its southern and eastern parts have been irregularly dislocated, volcanic action has diversified parts of the surface, and denudation has effected important changes in the complex uplifted mass: but the northwestern part is free from dislocation and from volcanic action, and there the uplifted surface of denudation is well displayed in an even plateau (abstracted chiefly from Depéret, Ann. de Géogr., i, 1892, 369-378). If stripped of its volcanic cones and flows and 'unfaulted', the plateau would have the form of a vast inclined plane, highest in the southeast, and descending very slowly to the northwest (Boule, in Joanne's Dictionnaire géogr. et admin. de la France, iv, 1895. 2538). The northwestern part of the plateau, unaffected by volcanic action, and not covered by the lacustrine formations that elsewhere rest upon it, exhibits a surface of crystalline rocks interrupted only by closely folded troughs of coal measures, whose outcrops are sharply cut across at plateau hight, as if the whole structure had been rubbed down by a great levelling machine. The perfect regularity of the uplands between Montluçon and Creuse is an excellent representation of the form that the whole extent of the plateau region must have had about the beginning of Tertiary time, before it was uplifted and dislocated. Long continued erosion had then reduced the region to a plain close to sea level, thus destroying a great mountain chain and leaving in its place a lowland composed chiefly of long belts of granitic rocks (Vélain, "Auvergne et Limousin, géographie physique," in " L' Itinéraire Miriam," Paris, 1897, 10).

These extracts make it clear that French observers regard the stratigraphic evidence of the Tertiary lake deposits as confirming the conclusion reached from the study of form alone; both lines of evidence show that the uplifted, dislocated, and

dissected plateau region of to-day was a lowland of denudation in Tertiary time.

The highlands of the Ardennes along the border of France and Belgium is another part of the ancient Hercynian range, greatly denuded. It descends southward, where it is overlapped by Mesozoic formations, among which the Cretaceous strata are of special interest in the present connection. A belt of coal measures extends from the Ardennes southwestward under the Cretaceous; shafts have been sunk through the Cretaceous to the coal measures at many points, and thus the form of the buried denuded surface has been determined with much accuracy. Gosselet's elaborate "Mémoire sur l'Ardenne"* (Paris, 1888) gives much information concerning both the buried and the unburied portions of the denuded mountains. The frontispiece shows the valley of the Meuse incised in the plateau, "everywhere leveled to the same altitude." Many sections in the text show the Mesozoic strata lying on the deformed and denuded Paleozoic rocks, but the basal deposits beneath the Cretaceous are usually not marine. Even under the Jurassic, there is a ferruginous clay with limonite concretions, thought to be of terrestrial origin (l. c., p. 802). Under the Cretaceous strata, the most general deposit is a layer of black pyritous clay with vegetal remains, taken to represent the soil of a pre-Cretaceous land surface. Fluviatile and lacustrine deposits are also recognized. The Carboniferous limestone is often pitted, and the pits contain non-marine materials and fossils. Where the intermediate deposits are wanting, the ancient rocks are perforated by boring mollusks and strewn with shells of oysters and serpulæ (p. 808, 810). On the uplands at a considerable altitude, and far beyond the main overlap of the Mesozoic cover, there are scattered remnants of Cretaceous and Tertiary deposits, and these are all regarded as of earlier date than the elevation and dissection of the plateau (p. 831). Fuller details as to the composition and distribution of these deposits are given in other papers by Gosselet (Ann. Soc. géol. du Nord, vii, 1879, 100) and Barrois (Ibid., vi, 1879, 340). Bertrand says that the buried pre-Cretaceous surface is a denuded plain, and that its existing irregularities are due, at least in great

*Ardenne is the name of a department of France; Ardennes, of the Highlands themselves.

part, to subsequent movements that the chalk also has suffered (Ann. des Mines, Jan., 1893, 36).

The different parts of the ancient mountains of the Ardennes overlapped by Triassic, Jurassic, Liassic, Cretaceous, and Tertiary formations, were doubtless exposed to denudation for different periods of time, and successively submerged in encroaching seas: it is quite possible that the dissected uplands of today were peneplained at a distinctly later date than was the floor beneath the Jurassic strata, and that the relation of the two is similar to the relation stated by Darton for the two parts (AB and BE, Fig. 1) of the ancient rocks of the Piedmont belt in Virginia. French writers do not seem to have occupied themselves especially with this question, either in the Ardennes or in the Central plateau. But on the other hand there seems to be no question that the stratigraphy of both the marine and the terrestrial deposits proves the existence in northern France of a denuded surface of small relief, whose larger part is now buried, and whose smaller part is elevated and more or less dissected.

Bohemia offers another remarkably good example for citation, as summarized by Penck and here freely rendered. A great mountain range once rose there, probably reaching an altitude of 5,000 meters. It was worn down to a comparatively even lowland before the incursion of the Cretaceous sea, by whose deposits it is now thinly covered, for freshwater formations are everywhere found under the Cretaceous strata. This relation is repeated in many other parts of Europe, especially where truncated old mountains are found. Terrestrial formations are their first cover, and upon these rest the later marine deposits. It follows from this that the truncated mountains of Europe were not denuded by the surf of ancient seas, eating into their hights and gradually wearing them away; for before the sea rolled over the old mountains they were already laid low and covered with terrestrial formations (Ueber Denudation der Erdoberfläche, Vienna, 1887, 23, 24).

While it may be true that there are to-day no extensive peneplains still standing close to the sea level with respect to which they were denuded, the examples given in this and in the preceding section seem to me to prove that the earth contains many approximations to the peneplain condition, inas-

much as it preserves some excellent fossil peneplains; and that the stratigraphic as well as the physiographic method of investigation yields abundant and accordant evidence of their occurrence.

B 5. *Plains of marine abrasion as well as of subaerial denudation are discarded.* It is worth while to point out explicitly that all these districts which have been for half a century past explained as uplifted and dissected plains of marine denudation (or of marine abrasion) by geologists and geographers in many parts of the world are to be otherwise interpreted by those who adopt Professor Tarr's argument. The even skyline, discordant with structure, has been the leading evidence for plains of marine denudation ever since it was introduced by Ramsay in his description of the hills and mountains of South Wales. For this reason it has seemed to me that others than those who accept the peneplain or subærial theory should have had more consideration in Professor Tarr's article; and for the same reason I have felt free to mention here certain denuded regions which have been interpreted as plains of marine denudation by the authors I have quoted. The marinists and the subærialists differ as to the agency by which an elevated region may be worn down to a nearly featureless plain, a little below or a little above sea level; but they are unanimous in recognizing the necessity of such plains when uplands of even skyline exist in regions of disordered structure. All such plains are swept away as fictions by Professor Tarr's argument; for although he says little about plains of marine denudation and confines his attention almost wholly to peneplains, it must be remembered that these terms (plain of marine denudation and peneplain) are in nearly all cases hardly more than different names for the same thing. If the whole truth were known, it is probable that one or the other name might be appropriately applied in this or that case, but it is seldom that anyone has succeeded in convincing all his contemporaries that he could distinguish a plain of marine denudation from a peneplain, or vice versa. On the other hand, all regions, heretofore explained as having passed through the condition of abraded or denuded plains, would be explained as never having reached a form of faint relief, if Professor Tarr's alternative theory be accepted. It therefore demands careful consideration, to which we may now turn.

C 1. *The alternative theory aims chiefly to explain the existing forms of New England rather than those of better finished and better preserved peneplains.* It is a matter of regret that a theory intended to replace the theory of peneplanation should have been tested by its author chiefly in New England, whose highest and most rugged parts are generally taken as examples of grouped monadnocks. I should not be at all disposed to say that the "peneplains of New England and New Jersey * * * have been most fully studied, and rest upon the firmest basis" (p. 353). Southern New England would have been a fairly satisfactory area, but when the White and Green mountains and the mountains of Maine are included, the example to be explained falls largely outside of the scope of peneplanation. The reference to Labrador (p. 366), as an area unfavorable to the peneplanation of New England, seems altogether aside from the case. However, if the alternative theory of mature dissection is really capable of supplementing the theory of peneplanation, it should suffice to explain not only rugged New England, but also the many better finished and better preserved peneplains in other parts of the world, some of which have been referred to above.

C 2. *The subequality of mountain hights.* The development of a rough equality in the hight of mountain peaks by the faster destruction of the higher summits, on account of the greater violence of weather changes and of the absence of tree and soil covering at great hights, has been announced by Penck (Morphologie der Erdoberfläche) and by Dawson (Geology of the Kamloops area, Geol. Surv. Canada, 1894) and is now independently suggested by Professor Tarr. ABC and ADE, fig. 2, are in this way changed to FGH and FJK. The processes appealed to are not identical in the explanations of the three authors, but not having the writings of the two former at hand, I cannot give details. The approach to equal hight of many peaks of different structure in a given mountain group may be thus explained, as in the Alps, or in the Rocky mountains of Colorado: if any one felt *per contra* convinced that this subequality might be the result of the deep dissection of a greatly elevated peneplain, the discussion would doubtless be interesting.

The subequality of mountain hights being once gained, all

the mountains are then under essentially uniform climatic conditions, and for the rest of their lives difference of structure will determine their rate of decay. All changes would truly be very slow, but small differences in rate of wasting would suffice to develop distinct differences of altitude while the mountains were worn down from the tree line to the farm line. The uneven hill and mountain districts about lake Winnipiseogee, N. H., might be evolved in this way; but it seems to me very doubtful whether any such equality of hight as prevails in central Massachusetts can be explained as an inheritance from an equality determined by climatic control when the region had a much greater elevation, for to-day these uplands are about 3000 feet below the tree line, and their structure is by no means uniform.

C 3. *The beveling of hill tops.* It is said that "by the time maturity of topographic form has been reached, there will be a beveling of hill tops where the harder gneissic and granitic rocks exist" (p. 368). I am not sure whether this and other references to beveling are correctly interpreted in what here follows, but the intended meaning seems to be that the hill tops would be somewhat flattened so as to imitate the broad uplands that are often found in (so-called) uplifted and dissected peneplains. That is, the conical form, FJK, would be changed to the beveled or truncated form, FVWK. Beveled forms of this kind are certainly common in central and western Massachusetts and in northern New Jersey; they are much better developed in such districts as the Piedmont belt of Virginia, the western part of the central plateau of France, and the uplands of the Slate mountains in western Germany. The broadly beveled upland, FMNK, would represent the type form in some of these examples. Not only are the ancient mountains beveled, but their beveled uplands fall in a systematic and accordant manner closely into a single plane, usually an inclined plane: There can be no question of the fact of such beveling, so far as existing form is concerned, in many well preserved peneplains; but no sufficient explanation of the process of beveling is given in Professor Tarr's article. It is briefly asserted. An explanation would be hard to find, unless it involved some especially active process, a function of altitude and climate, such as Richter has suggested for the

beveling of the upland fjelds of Norway by means of the broadening of *kahre* floors under the action of local glaciers (Sitzungsber. Akad. Wien, 1896?); but it is manifest that all such processes are applicable only at altitudes above 5,000 or 6,000 feet in New England, as Q, fig. 2, and hence cannot be directly concerned in producing beveled hill tops at altitudes of 1,000 feet or less. In uplifted peneplains, where the uplands bevel across from valley to valley, it is manifest, as has already been pointed out, that existing processes are engaged in destroying, not in producing or perfecting the uplands. Indeed, the production of beveled hill tops, as here interpreted, seems to me so inherently impossible that I am for that reason persuaded that all this paragraph must be aside from the intention of Professor Tarr's theory. And yet, unless the systematic beveling of hill tops is some how accounted for, the theory must fail to explain the most essential features of those regions commonly regarded as uplifted and partly dissected plains of denudation.

Perhaps the change of form intended under the term, beveling, applies only to the mountain slopes, so that FJK, fig. 3, becomes FLK. If so, it does not materially modify the changes considered in the last paragraph of section C 2, and it leaves unexplained the important feature that I should call "beveling of hill tops," as considered just above. I hope that this important matter will be more fully presented by Professor Tarr.

C 4. *Denudation and beveling will be more advanced near the coast than in the interior.* It is urged that near the coast, "mountains would have been more lowered than in the interior, and, in the coastal region, there may well have been an approach to the peneplain condition" (p. 366); and again that "this beveling of the hill tops would be very much further advanced near the coast than in the interior, thus coinciding with the conditions found in New England" (p. 368). The brief statement allotted to these important propositions must leave the reader somewhat in doubt as to their explanation. As far as I can analyse them, they are not applicable even to the case of New England, much less to various other cases cited above.

The ancient mountain trends of southern New England are obliquely traversed by the shore line of Long Island sound.

The ancient mountain structures show no sign of weakening as they approach the shoreline, and we may fairly suppose that there has been about as much denudation to be done there as further north. From southern New Hampshire, across central Massachusetts and Connecticut, there is no indication of a weakening of the rocks; a good variety of more or less resistant gneisses and schists occur all across this district. Difference of climate cannot be appealed to as a cause of faster denudation and beveling near the coast, for the climate is more severe in the interior. The streams are larger and the valleys are necessarily lower and broader near the coast than in the interior, but the interstream uplands are under essentially similar conditions in the two regions. A rough equality of mountain hights being established, as H, A, B, fig. 4, there is then no reason for the greater action of the weather on a square foot of surface at B than at A. The master streams having gained a graded slope, GEF, there is no reason for the denudation of A to hesitate at the hight C, a thousand feet above the streams, while B is reduced to D, only a hundred feet or less above the streams. Hence I have to conclude that whatever strength there may be in the propositions quoted at the opening of this section, they are not presented in a way to make it apparent. The tilting of a previously denuded surface seems a relatively simple and safe way of accounting for the relation of the upland and stream profiles, CD and EF, as has been suggested above (A6); but tilting has no announced place in Professor Tarr's theory. The omission of so commonplace a movement is the more curious, inasmuch as frequent movement of some sort must be characteristic of a theory that "requires no long periods of relative quiet" (p. 369).

C 5. *New England and New Jersey as maturely disected mountains, rejuvenated.* It is maintained that the regions especially under discussion have been "lowered to the stage of full maturity, then elevated and made more rugged," and that although the surface has always been mountainous, it was "once less mountainous than now, because of the recent uplift" (p. 365). There are various other parts of the world to which a similar description might be applied: the indication of full maturity being found in the well-opened valleys of the larger streams, ABC, fig. 5, developed with respect to a

former baselevel, MM; and the indication of "recent uplift" being no less apparent in the narrow gorges, D, incised in the floor of the maturely opened valleys, ABC, with reference to the new baselevel, NN. The essential evidence of such recent uplift and rejuvenation is found in benches E, F, on the compound valley slopes, AED and CFD. If rejuvenation were so long ago that this bench were destroyed by the development of continuous slopes, AGD and CHD, then the uplift could not be discovered by topographic evidence. It is on evidence of this kind that rejuvenation has been announced for the Susquehanna district of the Pennsylvania Appalachians, and for the Hudson valley; but no description has been published of any such evidence for the rejuvenation of New England. The deep valleys of many rivers in Massachusetts and Connecticut have no persistent benches on their slopes, and there is no visible reason for saying that any important pause was made in the elevation by which the former baselevel of the uplands, AC, was replaced by the present baselevel, NN, of the valleys, AGDHC. The rivers truly have many falls and rapids, due to their displacement from better graded courses by the irregular distribution of glacial drift, but this is quite another matter.

The valley-side benches are important items in the present discussion, if they exist at all; for when fully established they will define many interesting points. If high on the valley sides, as at A, fig. 6, (resembling the gorge of the Rhine) they would show that the previous cycle had gone far beyond maturity and well into old age before uplift occurred; if low down in the valley bottom, as at B (resembling the Frazer river valley in British Columbia), they are of trifling importance, as far as the present discussion is concerned. If the downstream slope of the benches were about parallel to the present profile of the rivers, a uniform uplift would be suggested; if distinctly not parallel to the present stream profiles, an uneven uplift would be implied. All these points should receive specific attention if the new hypothesis, which "requires no long periods of relative quiet," is to be accepted. As now stated, the recent rejuvenation of New England seems to me very open to question. There is no evidence of recent rejuvenation in the occurrence of a young coastal plain along

the coastal border, such as ordinarily accompanies recent uplift, unless the postglacial coastal plain of Maine be so considered; and that would hardly be permissible, for the existing valleys were eroded before the plain was formed.

C 6. *The alternate hypothesis takes no account of buried peneplains.* Professor Tarr's hypothesis, which "calls merely for a greatly reduced, but still markedly irregular surface" (p. 370), entirely fails to meet the case of well preserved peneplains, like that of the Piedmont belt in Virginia, and even more entirely fails to meet the case of buried peneplains, such as have been described above. The first example cited, that of the even floor on which the Carboniferous rocks rest in the Colorado canyon, is entirely beyond the reach of a theory that does not carry subaerial denudation further than the stage of maturity. If refuge is taken in the theory of marine abrasion, the several examples in France and Bohemia, where marine abrasion is excluded, remain to be explained. It must therefore be repeated that it is a matter of regret that a theory, intended to supplant the theory of peneplanation, should have been framed chiefly with respect to the rugged uplands of New England and New Jersey, and without sufficient consideration of the many other examples of better peneplains, buried and unburied, of which modern geological and geographical writings contain abundant descriptions.

The preparation of this essay has been greatly aided by the kindness of my geological and geographical colleagues in Edinburgh, London, and Paris. The completion of the essay in southeastern France has made it impossible to cite, as fully as I should like, certain pertinent examples, to which, however, there may be opportunity of returning if fuller consideration of the peneplain idea is called for by a continuation of this discussion.

Cannes, France, December, 1898.

NOTES ON THE CRETACEOUS AND ASSOCIATED CLAYS OF MIDDLE GEORGIA.*

By GEORGE E. LADD, Rolla, Mo.

The state of Georgia is well supplied with a large variety of interesting and economically important clays. None of these are more worthy of investigation, as regards both their geological occurrence and their physical properties, than those which are found traversing the central part of the state in the immediate vicinity of the "fall line."

This line, which is practically the boundary between the rocks of the Piedmont plateau and the stratified deposits of the coastal plain, traverses the central part of the state in a generally east and west direction and passes through the cities of Augusta, Macon, and Columbus.

Journeying across the state from one of these cities to the other by rail, or over the dirt roads, the fall line is crossed and recrossed many times, and the observer recognizes here the features of the Piedmont plateau, and there those of the coastal plain. On the Piedmont side appear the well rounded hills and deep red soils which characterize its ancient formations. Occasionally, and especially in the vicinity of streams, are bare stretches of crystalline rocks, while frequently in the gullies and road-way cuts various transitions are exposed between the fresh crystalline rocks and the products of its decomposition which constitute the soils. The schists are brilliantly colored, especially where decomposed, yellow and green shades predominating. The soil above the crystallines is comparatively fertile and yields abundant crops.

On the coastal plain where the highest elevation is about seven hundred and fifty feet, the well defined hills of the Piedmont belt are replaced by broad flat-topped plateaus and wide reaching terraces, the latter particularly predominating in the vicinity of the great rivers.

Occasionally streams and railroad cuts penetrate through the sedimentary strata to the crystalline rocks below, and it is often hard to distinguish where the one ends and the other begins, the lowest of the sediments being composed of the coarser elements of the underlying crystallines, large boulders of which frequently occur in the sedimentary beds.

*Published with the permission of the State Geologist of Georgia.

The Cretaceous beds, at least those of the Potomac group, are visible at many points in cuts along the Central railroad, particularly between Columbus and Macon, and for many miles east of Macon both on the Central and the Georgia railroad. They consist mainly of white clays and sands, sometimes wholly differentiated from each other. The clay is remarkably free from grit or sand, and the sand beds in turn are often entirely free from impurities of any kind.

The Tertiary beds are exposed at many points along the dirt roads, chiefly east of Macon. Excellent sections of fossiliferous marls of Eocene age are exposed in the railroad cut at Summit in the southern part of Jones county.

The Lafayette and Columbia sands which over-spread the coastal plain may be seen the whole distance of the fall line, where they have smoothed out the minor irregularities of the old land surface. They make a less fertile soil as a rule, than is found on the Piedmont side of the line.

The Lafayette gravels are characterized by cross-bedding, rapid transition from coarse to fine materials, and, generally, by a deep red color resulting from the oxidation of iron bearing minerals. It frequently has a mottled appearance which is noticeable in the sides of gullies and cuts. The prevailing red color is frequently broken by a net work of grayish shades where the iron oxide has been "reduced" by organic compounds resulting from the decay of the roots of trees and shrubs.

One of the most interesting sections along the fall line belt is at Rich hill, which has an elevation of seven hundred and fifty feet, is capped by Lafayette materials, and exposes in deep gullies on the southern side, one hundred and fifty feet of Tertiary strata, resting uncomformably upon the white Cretaceous sands and clays of its base.

Before the deposition of the great thickness of Tertiary upon the Cretaceous, much of the latter, especially along its land margin, was eroded, and re-deposited in the Tertiary seas. The subsequent removal of the Tertiary and overlying strata, has brought the Cretaceous rocks to the present surface over a considerable area in the western part of central southern Georgia.

On the old geological maps of Georgia the Cretaceous de-

posits are outlined as occupying a triangular area in the central western half of the state, the northern boundary being the fall line, and extending from Columbus, on the west, to Macon in the center of the state, the western boundary being the Chattahoochee river and the southern or eastern half extending from a point in the vicinity of Fort Gaines to Macon.

A careful study of the base of this formation, that is, the Potomac, which is composed of clays, sands, and gravels, has convinced the writer that its beds continue in an easterly direction across the state, following approximately, the fall line, and passing into South Carolina through Augusta. It furnishes clay of great economic value.

Associated with the Potomac clays are the clay products resulting from the decomposition of the gneisses and schists of the Piedmont belt, which now furnish clays, in situ, and in low places where the washings from the hills accumulate, suitable for many common uses, and also a variety of clays belonging to the Tertiary period as well as those occurring in the Lafayette mantle, which are derived in part from the Piedmont belt and in part from the underlying strata. From them may be made a high grade building brick, and a comparatively low grade refractory ware. As a rule, however, these clays are sandy and full of impurities and their use is rarely more than for local purposes. They furnish, however, material which is often used to mix with other clays, especially such as are to be found in the same vicinity, and which are by themselves too "fat" or plastic.

On some of the terraces, particularly in the vicinity of the rivers such as the Savannah, Oconee, Ocmulgee, Flint and Chattahoochee are clay beds belonging to the Columbia formation, which furnish a material now largely used in the manufacture of bricks.

The most interesting of the fall line clays and by far the most important from a commercial standpoint, are those of the Potomac group. Some of the other clays, however, are remarkable in many respects. For example, a certain Tertiary clay, which is hard and tough and cuts with a knife much like wax, has a specific gravity so low that it readily floats on water. Others are noteworthy for their extraordinary colors, great plasticity, large amount of shrinkage on drying and the enor-

mous tensile strength of the air dried briquettes. Nevertheless the presence in these of a considerable amount of fluxing impurities renders them of small commercial value, with the exception always of the Columbia brick clays.

The Potomac clays are valuable for two reasons. First, because they are extremely pure as regards fluxing impurities, which adapts them especially for the manufacture of refractory wares, and in the second place because, over large areas, these clays, otherwise pure, are also wholly free from grit or sand, and because they are friable and easily broken up into an incoherent mass of fine particles, while they are practically as white as snow. They are thus fitted for the demands of the wall paper trade, the manufacturers of which are large consumers of this kind of clay, paying as high as from $8 to $12 per ton.

In South Carolina a few miles from Augusta, Georgia, this clay is extensively worked for the wall paper industry, while in Georgia development is going on and shipments being made from at least three different localities along the fall line. One company has opened a bed in the vicinity of Butler, another at Dry Branch, near Macon, and a third in Wilkinson county, at Lewiston.

The clay beds are all easily worked. In some cases in old fields they are entirely free from stripping and the white chalk-like clay is exposed at the surface. In other cases an overburden of Lafayette sand and gravel occurs, varying in thickness from 12 to 20 feet. The overburden, where necessary, is removed in wagons until the surface of the clay is exposed over a considerable area. This surface is then carefully scraped and swept until entirely free from the presence of grains of sand. The clay is then worked in open cuts, and sorted out under the direction of trained men. That which contains sandy impurities is entirely discarded, and the remainder classified according to the density and freedom from color (the pure white being the most valuable). Three colors are sold to the wall paper trade, pure white, that which is faintly grayish, and a third grade having a slightly grayish or bluish tint. The clay is stored in drying sheds and after being thoroughly dried is broken up and packed solidly into enormous casks for shipment. The clay is usually cream colored when first taken from the pit, always becoming lighter and usually becoming

quite white on drying except of course in the case of some of the beds, particularly in the western part of the state, where it is mottled red and blue.

The most wide-spread impurities which occur in the Potomac clays are scales of mica, usually muscovite, and minute crystals of magnetite. Both of these may frequently be seen with the naked eye, and the magnetite is sometimes so abundant as to give a slightly bluish tint to the mass. An average sample of the better grades of this clay is fine grained and tough, has a characteristic argillaceous odor and a soapy or fine mealy feel. Its hardness is about that of chalk. It absorbs water readily and disintegrates rapidly, becoming somewhat plastic.

The following tables and descriptive notes show the chemical and mineralogical composition, physical properties, geological age, and manner of occurrence of a few typical clays found along the Georgia fall line.

The analyses and physical tests were made by the writer.

The samples described here are designated by the name of the locality or property, in the vicinity of which they occur.

The Griswoldville Clay. Griswoldville is situated on the Central railroad about ten miles east of Macon.

The white Potomac clays are seen here at many points along the railroad, in cuts, and in gullies and old fields in the vicinity. While it frequently occurs at the surface it is usually buried beneath Lafayette beds, varying in thickness from ten to twenty feet. The terrace along which the beds occur is about one hundred feet above the Ocmulgee bridge at Macon.

The hills which rise above this terrace are composed of Tertiary strata mantled with Lafayette, and have an average hight of one hundred and sixty feet above the plain, or two hundred and sixty feet above the terrace upon which the city of Macon stands.

From the railroad cut at the Griswold station a large amount of clay has been removed and shipped to Chattanooga, Tenn., for manufacture into fire brick and other refractory wares.

The chief characteristic of the clay beds, here, is irregularity. They frequently grade off into white sands and gravels and are occasionally cut out by the unconformably overlying beds of Lafayette.

CHEMICAL COMPOSITION.

Name of Clay	Loss on Ignition	Combined Silica	Free Silica	Alumina	Ferric Oxide	Lime	Magnesia	Potash	Soda	Total	Hygroscopic moisture	Geological Age.
Griswoldville	13.08	44.94	1.23	39.13	0.45	0.18	0.11	0.51	0.63	100.45	0.57	Cretaceous
Miller	14.52	42.79	0.82	40.42	0.80	0.37	0.00	trace	0.83	100.45	0.21	"
Stevens Pottery	13.64	43.85	2.77	38.28	1.02	0.18	0.00	0.05	0.08	99.87	0.72	"
Summit	19.41	13.62	36.80	11.56	2.20	13.89	1.73	trace	1.36	100.57	3.64	Tertiary
Fitzpatrick	11.24	54.39	6.89	14.64	0.28	7.08	1.71	4.23		100.18	8.70	"

Name of Clay	Kaolinite	Feldspar	Quartz	Muscovite	Biotite	Magnetite	Titanite	Hematite or Limonite	Calcite	Pro-Chlorite	Organic Matter
Griswoldville	About 97%		Rare	Few scattered cleavage crystals		Few small Crystals					
Miller	About 97%			Few extremely minute scales							
Stevens Pottery	About 90%		Occasional grains revealed by high powers*	Comparatively rare						Traces throughout the clay	
Summit	About 80%		Abundant up to $\frac{1}{1000}$ of an inch in diameter			Abundant $\frac{1}{60}$ - $\frac{1}{80}$ of an inch in diameter		Abundant	Considerable		Abundant
Fitzpatrick	About 35%	Abundant	Abundant up to $\frac{1}{60}$ of an inch in diameter	Many prisms and cleavage scales	Considerable	Occasional Crystals	Rare				

*None over $\frac{1}{2000}$ of an inch in diameter.

RESULTS OF PHYSICAL TESTS.

	Water absorption	Shrinkage on drying	Shrinkage on burning	Fusibility	Tensile Strength, dried, per sq. inch.	Specific Gravity
Griswoldville	112%	8%	3½ to 4%	Seger cone No. 36–*	25 lbs.	1.76
Miller	80%	4½%	4%	Seger cone No. 36–	10 lbs.	1.91
Stevens Pottery	100%	8%	2%	Seger cone No. 35.	24 lbs.	1.72
Summit	98%	18 to 20%	2%	1100° C.	304 lbs.	1.90
Fitzpatrick	200%	25%	6%	1330° C.	213 lbs.	0.90

An average sample taken from one of the workable beds is white in color, when dry, and very fine grained. Muscovite scales can only be detected by use of the lens. Grains of quartz are extremely rare and only to be seen under the microscope with a high power. The microscope shows it to contain but little muscovite and to be one of the purest clays of the fall line belt. It readily absorbs water and becomes plastic.

Miller Clay. The Miller clay occurs on the property of L. F. Miller, which is situated about 3 miles south of Gordon. The thickest bed seen in Georgia of the white Cretaceous clay is here exposed. A section along the slope of the hill shows at its base thirty feet of the white Cretaceous clay unconformably overlaid by one hundred and twenty feet of massive Tertiary clays which in turn are unconformably overlaid by orange and vermilion sands probably of Lafayette age.

The clay examined and analyzed is remarkable for the presence of an abundance of pear-shaped areas, averaging three-fourths of an inch in greatest diameter, and consisting apparently of a finer grained, darker colored clay material. This clay is also noteworthy on account of its property of hardening on exposure to the atmosphere. Often for several feet from the surface it is exceedingly hard and tough, being difficult to

penetrate with a pick. This property leads to a considerable use of the material in the construction of chimneys, the soft clay being trimmed into blocks with an ax and exposed to the weather for a few weeks or months, during which time it becomes hard and very tough.

Stevens Pottery Clay. This clay occurs at a town known as Stevens Pottery, which is situated in Baldwin county, on a branch of the Central R. R., and which received its name on account of the clay manufacturing plant of Stevens Brothers, located there. The firm which consumes the clay is the largest producer of sewer pipes and pottery in the state.

The clay occurs much as at other points along the fall line, but as a rule carries a considerable amount of impurities in spite of which, however, it is more readily used for manufacture into common wares, it being more plastic and more susceptible to burning, although as a fire clay it fuses at a slightly lower temperature than the high-class, refractory clays found at other points in the Cretaceous belt.

Summit. This clay occurs at a point about six miles northwest of Griswoldville and somewhat north of the fall line. It is part of an outlier of Tertiary strata resting on greatly distorted crystalline schists, which are here cut by a thick, fine-grained diabase dike.

The elevation of the occurrence is about two hundred and fifty feet above the Macon bridge. The clay beds are exposed in the railroad cut to a depth of thirty feet or more. They have a bluish and greenish color, and in places are densely packed with shell fragments which furnish a large amount of the calcite shown by analysis to be present. The clay is capped by the omnipresent beds of Lafayette gravel. The material which was analysed and tested was free from fossil remains.

Fitzpatrick. Fitzpatrick is a station on the M. & D. R. R. about ten miles southeast of Macon.

The clay selected for study from this locality was taken from stratum No. 5 of the following section:

1. Yellow soil, grading downwards into red sand ......10 to 12 feet
2. Laminated clay .... 5 feet
3. Fine sand with carbonaceous layers (2 to 3 inches thick).. 6 feet
4. Grayish laminated clay .... 4 feet
5. A white to cream colored clay which dries to a hard punky condition, is exceedingly tough and can be cut

and carved to a remarkable extent even when perfectly dry. It breaks with a conchoidal fracture and the joint planes are concentrically arranged. The joint planes are stained with iron oxide and the bed permeated with veins of greenish colored sands........ 12 feet

6. Green laminated clay, very plastic and containing black carbonaceous layers .... 8 feet

A hand specimen shows a white to grayish clay with sometimes a yellow to greenish tint, and having occasional stains of iron oxide along the joints. When dry, although exceedingly hard and tough, it cuts easily, and when cut it shows a smooth glossy surface which takes a good polish. In spite of its toughness it is porous, almost as light as cork, floating readily on water, although when placed in the water it slowly moistens, becomes pasty and, after a few minutes, sinks. Some scales of muscovite may be seen with the naked eye. The clay is not very plastic.

Under the microscope there appears in this clay, a large amount of foreign materials, which consists largely of rounded grains of quartz, the largest being one-one hundredth of an inch in diameter. Occasional magnetite grains occur and also plates and prisms of muscovite and angular fragments of feldspar. There are also a few small areas of a yellow colored mineral which seems to be titanite but which were not identified with certainty. In addition to these impurities there occur occasional fragments of an isotropic, colorless mineral, most likely basal sections of biotite. The clay particles are more or less bound together in little aggregates.

Its specific gravity varies from 0.90 to 1.20, averaging near the former amount. Experiments with the dry powdered clay prove it to have an enormous absorptive power, the clay taking up over two hundred per cent of its own weight of water. It shrinks on drying twenty-five per cent linear measurement. A dried briquette shows an average tensile strength of two hundred and thirteen pounds per square inch.

On burning the dried clay shrinks an additional 6 per cent and burns from a buff to a pale yellow color, easily crackling, and fusing at a temperature of 1330 degrees C.

[Contributions to the Mineralogy of Minnesota. VI.]

THE OPTICAL CHARACTERS OF JACKSONITE.

By N. H. WINCHELL, Minneapolis, Minn.

Jacksonite. In the collections of the *Muséum d'Histoire Naturelle*, Paris, is a fine specimen of the mineral named jacksonite by Whitney, and it is by the courtesy of Prof. A. Lacroix that a note on this specimen is here included. It was received in 1865 (No. 65.8) by purchase, and there is no sign of any artificial calcination which Dana suggests may have operated on that which was analyzed by Whitney. The speciman consists of two or three laminations of jacksonite with green rock substance, and is recorded as from Isle Royale, labelled "prehnite, sans eau." It is but rare that a fine radiated spherulite is discoverable in the specimen, but the mass appears compact and homogeneous. Its color is nearly white but has a faint tinge of pink. It is very hard and very firm.

According to Whitney's description* jacksonite is associated with wollastonite, both at the Cliff mine, Keweenaw point, and at Scovell point, Isle Royale. It was named by Whitney in honor of Dr. C. T. Jackson, "whose name is so well known in connection with the lake Superior region, and to whom we are so much indebted for our knowledge of its mineralogy." The description given by Whitney may be summarized as follows:

Jacksonite occurs in finely radiated and lamellar-radiated masses of a white color, slightly tinged with green. Its hardness is 6. Specific gravity 2.881. Lustre vitreous, translucent.

The finely pulverized mineral is perfectly, though slowly, dissolved by chlorohydric acid, the silica separating in the form of a flocky powder. Before the blowpipe in the platinum forceps it fuses very readily with strong intumescence and emits a brilliant yellow light. A large quantity of soda dissolves it readily; if more of the assay be added it swells up to an infusible slag. It gives with borax a colorless, transparent glass; with salt of phosphorus a glass enclosing a siliceous skeleton, faintly tinged with iron.

The analysis of the "ignited" mineral gave:

*Jour. Bost. Soc. Nat. Hist., V, 488, 1847.

Silica	46.12
Alumina and a little Fe_2O_3	25.91
Lime	27.03
Soda	.85

No water is reported in this analysis, although the statement is made that after drying at 100°cent. it showed less than 1-10 p. c. of water.

It is from this analysis that this mineral has been considered "sans eau," but it is quite probable that at the heat of ignition its water was driven off. Later determinations by Jackson and Brush, assigned from 4 to 5 per cent of water to jacksonite.

Two slides of jacksonite have been examined. Neither of them shows a finely spherulitic structure, as such spherules are quite rare, but a close, confused and short-fibre structure. The fibres are rarely parallel, showing but little elongation. They are always of the same sign (positive) thus indicating that the axial plane is parallel with the fibration. The double refraction is very nearly the same as that of lintonite. Indeed, the aspect of the mineral, as viewed under the microscope, is very similar to that of lintonite, the only difference being in the sign of the bisectrix with respect to the fibration. The extinction angle is very small, and sometimes is O°, but owing to the fineness and the overlapping of the fibres it is impossible to state its maximum in degrees. The mineral, therefore, seems to be monoclinic with the axis n_g nearly parallel with the fibres. This pink variety has lower sp. gr. than the green, viz. 2.68.

This mineral, therefore, has optic characters quite different from those of prehnite, mesolite and thomsonite, and but slightly different from those of lintonite. There is need of further chemical analyses of both these substances. If they should prove to be of the same species, lintonite, being later, should give way to jacksonite.

ANCIENT GLACIAL ACTION IN AUSTRALASIA.

By Prof. CHARLES H. HITCHCOCK, LL. D., Hanover, N. H.

A recent trip to Australia and New Zealand has induced me to collect the existing evidence relative to the presence of glaciers in Australasia at the end of the Permian or early in the Triassic period. The general conclusion attained is that ice action prevailed at about that period in Victoria, New South Wales, South Australia, Tasmania, southern India, and South Africa, but not in New Zealand. From the study of the fossil plants it has been imagined that these same countries had a geographical connection in Permian times; and to this hypothetical continent, which probably included the Antarctic regions, Suess has given the name of Gondwana Land. If glaciers existed so widely, it is probable that these lands were greatly elevated above the existing conditions, perhaps enough to lend some confirmation to this hypothesis of a vast southern continent. My object now is merely to collate what relates to the presence of glaciers thus early in geological time.

So long ago as 1857, Prof. A. C. Ramsay advocated the existence of a Permian glacier in England. I have studied the specimens gathered by him in support of this theory, in the Museum of the Royal School of Mines, Jermyn street, London, and accept the conclusions suggested. It would be impossible to distinguish the glaciated pebbles and the striation from the similar phenomena constantly presented to us in the work of the great Pleistocene sheets of ice.

Quite recently Prof. B. K. Emerson exhibited to the Geological Society of America a fine example of a glaciated boulder, perhaps ten inches in length, from a Mesozoic deposit in southern India. This I suppose to have come from one of the localities described by the government geologists of India; and certainly it gives an air of probability to their suggestions.

VICTORIA.

My first sight of glacial phenomena in Australia was in the Museum of the School of Mines at Bendigo, Victoria. Captain Thompson, director of this school, has collected specimens of glaciated stones from several localities many miles apart, and is greatly interested in their study. He almost thinks he can make out a moraine from the outcrops near Bendigo.

and says that the sources of the large granite boulders have not yet been discovered. Very likely they have been concealed by later Mesozoic or Cenozoic deposits of marine character.

Mr. E. J. Dunn, in a report upon the Bendigo gold field for 1892 (reprinted in 1896), has the following about one locality of these glacial conglomerates:

> On the west side of Kangaroo gully, and opposite Opossum gully, an outlier, a few chains in length and from one to two chains wide, of conglomerate that is referable to the same age as the Wild Duck Creek conglomerate occurs; it does not appear to be of any great depth, and in age may be of Permian or later date. In a more or less clayey matrix, in part rudely stratified, and in indurated fine gravel, are well rounded pebbles of quartzite, derived from Devonian conglomerate, hard grey sandstone in angular blocks, small fragments of schist, etc., the pebbles and fragments with the longer axes as frequently nearly vertical as horizontal. Veins of pale yellow chalcedony occur penetrating the clayey matrix; no other outlier was noticed in the vicinity of a similar character. The conglomerate is very distinct from, and in no way to be confounded with, the Tertiary conglomerates; it is the last vestige of what may have been a very extensive deposit.

The earliest reference to ice action in Victoria was in 1866, when Sir R. Daintree called attention to the probability of a marine glaciation (icebergs) to account for the formation of conglomerates near Darley, at Bacchus Marsh, Wild Duck river, and other places, near the close of the Permo-Carboniferous. This view was confirmed shortly afterwards by A. R. C. Selwyn, who was later the Dominion Geologist for Canada. R. D. Oldham agreed to these same conclusions twenty years later, speaking of them as being due to "moraine glacial transport," stating that they are the equivalents of the similarly formed Talchir beds of India, and affirming that they "contain abundant evidence of the action of floating ice" (Records, Geol. Survey of India, vol. XIX). Oldham also correlated these beds with others occurring in the Newcastle deposits, New South Wales.

Mr. E. J. Dunn presented the subject of these conglomerates before the Australasian Association for the Advancement of Science in 1890. He stated that this conglomerate is spread over a wide area along the dividing range, as at Bacchus Marsh, Wooragee, Wahgungah, Rutherglen, The Springs, El Dorado, Tarrawinga, Badaginnie, Wild Duck Creek, Carisbrook, and the Gardens. It is over one hundred feet thick. The

materials are various granites, gneiss, schists, and quartzytes. The material "ranges in size from the finest silt up to great blocks several feet across, and weighing in some cases probably from twenty to thirty tons. From the well rounded, almost polished pebble boulder to the rough angular fragment of rock that has been torn from its parent mass and not subsequently abraded, all are represented in these conglomerates. . . . Not only are the pebbles, etc., scored and scratched, but great numbers are rubbed on one or more sides (facetted)."

I had the pleasure of conferring with Mr. James Stirling, government geologist for Victoria, who has explored many of these localities, and especially others of a later period, which are not here considered. I understood him to express opinions confirmatory of the work of the gentlemen whose names have been cited.

SOUTH AUSTRALIA.

In 1877, Prof. Ralph Tate described, before the Australasian Association, the phenomena of glaciated character at Hallet's Cove, south of Holdfast bay, in St. Vincent gulf. This is in south lat. 35° and the surface planed is now only forty feet above sea level. He says:

The path of the glacier (?) is traceable for a distance of two miles along the top of the scarped cliffs, at about forty feet above the sea level; on the north it is cut off from the cliff by encroachment of the sea; from this point the glaciated surface is continuous in a southerly direction for a distance of one mile to Black point, the north headland of Hallet's Cove. On the line of the glacier there intervenes the long but narrow bay of Hallet's Cove, but to the south headland the track is picked up on about the same trend, though apparently at a little higher level. Here again the glacier (?) path is soon cut out by removal of the cliff. On the north side of the cove the glaciated surface is beautifully displayed; the edges of nearly vertical strata are sheared off, and when of quartzite the surface shows a high polish, and when of mudstones conspicuous grooves and striæ. Some moraine debris, including stones that have been beneath the glacier (?), occurs here. On the south side moraine matter is very abundant, and includes many boulders. . . . The common rocks of the moraine debris are granites, gneiss, hornblende schists, and others which do not occur in situations nearer than the gorge at Vormanville, about forty-six miles to the south. In all, seventeen distinct variations of rock, chiefly metamorphic and foreign to the neighborhood, have been collected along the path of the glacier. The proximity of the Miocene escarpments suggests the possibility of the pre-Miocene age of the glacier.

Professor Tate also refers to Mr. Selwyn's early observations of phenomena discovered farther south in the valley of the Inman, Cape Jarvis peninsula, who says that the direction of the grooves and striæ is east and west, in parallel lines following the course of the stream. Rounded surfaces of mica slate on the south flanks of the Kaiserstuhl and other parts of the Adelaide chain are less satisfactory, although suggestive as collateral supports.

Mr. R. Etheridge, Jr., has personally examined the classic locality at Hallet's Cove, and is quoted as believing it to be not improbable that the glaciated rocks extend beneath the marine Tertiary.

TASMANIA.

In 1884, Mr. R. M. Johnston communicated to the Royal Society of Tasmania the discovery of evidences of ice action in rocks of Permo-Carboniferous age at Maria island, consisting of erratics exceeding one ton in weight. This island is about fifty miles easterly from Hobart. Two years later he discovered similar erratics and polished blocks of the harder rocks foreign to the neighborhood at One Tree point, on Bruny island, south from Hobart. Still later he has found abundant evidences of similar nature in the same terrane in many other places in southeastern Tasmania.

An excellent summary of all that has been discovered of ice action in Australasia is given by Mr. Johnston in the Proceedings of the Royal Society of Tasmania for 1893. Concerning these Tasmanian exposures, it is noted that the ice-borne conglomerates occur in more or less barren layers of the lower marine beds known locally as "Mudstone rocks." In numerous localities, including Blackman's bay, Variety bay, Adventure bay, Esperance, etc., the erratics are associated in dense, white or yellow, close-grained mudstones, containing many organisms, of which I will only mention the genera, namely, Spirifera, Terebratula, Sanguinolites, Pachydomus, Edmondia, Aviculopecten, Tellinomya, Platyschisma, Orthonota, Astartila, Theca, Goniatites, and the fern Gangamopteris. The erratics are not associated with the finely laminated zones which are almost wholly made up of the remains of the common lace-like Fenestellæ. The polished boulders mostly occur in what must have been at the time of deposition an exceeding-

ly soft and fine homogeneous mud without signs of lamination. The rocks include polished or angular pebbles, blocks over a ton in weight down to fine pebbles, and are various granites, gneiss, quartzytes, mica schists, and slates, all of foreign origin. The larger blocks of granite or quartzyte generally occur singly, as if they had been quietly dropped on the soft muddy floor from floating ice. Their polished sides plainly indicate ice action.

It is possible that some of the thick conglomerate beds of the vicinity of Mts. Tyndall, Lyell, and Owen, in which marks of ice action have been recently discovered by Messrs. Dunn and Moore, may yet prove to be Permo-Carboniferous.

NEW ZEALAND.

The New Zealand geologists do not recognize any glacial action in their field analogous to what has been described in Australia and Tasmania. They ascribe the earliest known phenomena of this sort in New Zealand to the Tertiary and possibly Cretaceous. It is a matter of great significance that they refer the most vigorous glaciation to the later Tertiary.

I have not referred to other signs of ice action, in all the provinces spoken of, which are more nearly referable to the Great Ice Age, as commonly understood, just preceding the later Quaternary. That is far more consequential than what has been mentioned, so that it deserves a separate article; and it was more significant in New Zealand than elsewhere. Glaciers still remain there, along the Southern Alps, in dimensions and interest fully equal to those in Switzerland. Near the southern part of the larger island, the high mountains are intersected by fjords, which may have been filled with glaciers in the earlier period; but the proofs of such presence are entirely wanting.

RELATION OF GLACIATION TO CHANGES OF THE FLORA.

Mr. Johnston believes that the glacial epochs harmonized with great cycles of change in the plant life of Australia and Tasmania. Thus the original Carboniferous flora contained the following genera, none of which reappeared in the strata overlying the boulder deposit, namely, Glossopteris, Gangamopteris, Noeggerathiopsis, Schizoneura, and Lepidodendron.

One would think, however, from the large number of American Carboniferous genera recorded in the Mesozoic of this region, that the paleontological break may have been exaggerated, as the following list of Australasian Mesozoic genera may indicate: Pecopteris, Neuropteris, Sphenopteris, Thinnfeldia, Cyclopteris, Tæniopteris, Odontopteris, Sagenopteris, Alethopteris, Phyllotheca, Annularia, Podozamites, Pterophyllum, Otozamites, Sphenozamites, Brachyphyllum, Taxites, Sequoites, Walchia, Cunninghamites, Araucarites, Baiera, Salisburia, Ginkgophyllum, and Zeugophyllites.

At the close of the Mesozoic era in this region, all its rich and varied flora in turn disappeared, to be succeeded by new forms. This change was isochronous with important eruptions of the later greenstones, and some indications of attendant glacial phenomena are discovered.

CONCLUSIONS.

1. Glaciers must have existed in Australasia, India, and South Africa, at about the close of the Permian and opening of the Triassic period.

2. An elevation of from 8,000 to 10,000 feet above the present sea level, under existing climatic conditions, would seem to be required to allow glaciers to accumulate.

3. If these various countries were united by land areas in the Triassic period, with the possible additions of South America and Antarctica, the greater part of that early continent must have been depressed abnormally in later times, with no apparent relation to existing land.

4. These early glaciers probably were not of great consequence, as their locations correspond, in nearness to the equator, with those of Pleistocene glaciers in Syria and northern Africa. They do not seem to have been continental in their dimensions.

5. If there have been several periods of cold, interspersed with times of tropical heat, there will be a greater necessity for the invocation of astronomical causes for the lowering of the temperature.

EDITORIAL COMMENT.

CAUSES OF GLACIATION.

In ascertaining the causes of the climatic changes which have permitted the accumulation of glaciers and ice-sheets on large areas of the present torrid and temperate zones, two great periods exceptionally characterized by glaciation are to be considered, occurring respectively near the close of the Paleozoic and Tertiary eras. Although millions of years separated these glacial periods, there was no similar extension of glaciers and ice-sheets during that very long interval, nor probably at any time preceding the Permian glaciation. The evidences of that early glacial period, found in the tropical regions west, north, and east of the Indian ocean, were well stated by David White, with the bibliography of this subject, in the AMERICAN GEOLOGIST for May, 1889 (vol. iii, pp. 299-330); and they are again brought to our attention in the present number by Prof. Hitchcock, and by the review of Dr. Molengraaf's recent study in the South African Republic.

The causes of the widely separated Permian and Pleistocene glaciations appear to be indicated by other geologic conditions belonging to the same periods. Their great epeirogenic movements, with the upfolding of long and massive mountain ranges, were probably sufficient, by the altitude given to the areas which became ice-enveloped, to account for their climatic changes and glaciation. This view was published by the present writer ten years ago, as an appendix of Wright's "Ice Age in North America;" and again five years ago it was included in the ninth chapter of "The Glacial Lake Agassiz" (Monograph XXV, U. S. Geol. Survey). It appeals to deformations of the earth, giving high altitudes of large areas by lateral pressure of the crust, previous to the birth or further growth of mountain ranges; and it is consistent with the doctrine of the general permanence of the continents and oceans, because the lateral pressure could be relieved only by uplifts of parts of the continental areas with corresponding depressions of parts of the ocean basins.

Support of this explanation of the causes of accumulation of ice-sheets seems to me to be given by the close associ-

ation, in the period ending the Paleozoic era, of vast epeirogenic and orogenic changes with widely extended and long continued glaciation. Again, in late Tertiary and Pleistocene time, great continental uplifts were attended with the second and only other great period of ice accumulation known in the geologic record. Measures of the uplift of North America at that time, 3,000 to 5,000 feet above its present altitude, are afforded by the submerged valleys made known by Lindenkohl, Dana, and Spencer, on our eastern shores, and by Davidson on the Californian coast, from the detailed hydrographic work of the United States Coast Survey. Likewise on the western shores of Europe and Africa fjords and submerged valleys prove a late uplift of a great part of these continents 3,000 to 6,000 feet, and in one tract even 8,000 feet, higher than now. These valleys reaching far beneath the present sea level prove indisputably a former very great elevation of the regions of Pleistocene glaciation, and, east of the Atlantic, its continuation into the torrid zone, far beyond the limits of that glaciation. The coincidence of such exceptional epeirogenic movements and glaciation of large parts of the uplifted regions, occurring only twice and so widely apart in the earth's history, points clearly to their relationship as cause and result, the snow and ice being amassed on the uplifted lands because at their high altitude the storms brought mainly snow, instead of rain, at all seasons of the year.

W. U.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

The Glacial Origin of the Dwyka Conglomerate. By Dr. G. A. F. MOLENGRAAF, State Geologist, South African Republic. (Trans. Geol. Society of South Africa, vol. iv, pp. 103-115, with two plate views from photographs, and two sections; Oct., 1898.)

The author opens this paper by disclaiming any supposed glaciation in South Africa during the Quaternary era; but he confidently affirms that a far earlier glaciation prevailed there upon a very large area, probably during a part of the Permian period. The Dwyka conglomerate, forming the base of the Karoo system, has pebbles and boulders up to several tons in weight, imbedded in a matrix which weathers into

a buff-colored tough clay. The boulders often have one side worn and polished, and these surfaces occasionally bear parallel striæ. In its thickest deposits of the district here considered, ranging up to sixty feet, the conglomerate is perfectly unstratified; but it alternates with stratified beds, which sometimes inclose many boulders and pebbles, but occasionally none. The glacial origin of this formation was first suggested in 1868 by Sutherland, and has been accepted by Schenck, Griesbach, and Dunn; but Prof. A. H. Green (in 1889) and others reject this view, being more inclined to regard the conglomerate as a beach deposit from sea-cliff erosion, or as of igneous origin.

Dr. Molengraaf's observations in the Vrijheid (or Vryheid) district, where the Dwyka conglomerate is very well developed, convince him of its glacial character. This district, having an extent of about 75 miles from north to south, is crossed centrally by the parallel of 28° south latitude. The conglomerate is underlain by striated rock surfaces, one of which, very evidently glaciated, is shown in the first plate of this paper. The striæ bear N. 28° W., as referred to the true meridian, the direction of the glacial movement having probably been thus northwestward, trending toward the present interior of the continent. The ancient drift which lies on the striated rocks is described by the author as follows:

"All investigators agree that the Dwyka conglomerate possesses macroscopically all the peculiarities known to belong to a glacial boulder clay, with this difference, that the clayey matrix has been converted into solid rock. . . . . Of late I have had occasion to examine slides of Dwyka conglomerate from different localities, and I came to the conclusion that originally the matrix of the Dwyka must have been a mud containing numerous small, angular fragments of different rocks and minerals, chiefly quartz; that, however, the originally perfect clastic structure has been much modified by recrystallization, which gives the rock great resemblance to a volcanic tuff or breccia."

In the final paragraph of this paper, Dr. Molengraaf refers to the broad extent and great thickness of this conglomerate, from which he infers that the Permian glacial period in the southern hemisphere surpassed the Pleistocene glaciation of Europe and North America. He writes: "I firmly believe that the glacial theory will lead to a full and correct insight into the mode of formation and the character of the lower Karoo beds, but we should never forget that the old (Permian) glaciation of the Antarctic continent must have been of greater importance than the well known Quaternary glaciation of the northern hemisphere. So, of course, we find all the effects of this glaciation on a more gigantic scale than in the northern diluvium, and indeed we have to accept an enormous thickness of the ice-cap and a long duration of this Antarctic glaciation to be able to explain the enormous thickness (the Dwyka conglomerate is in many places more than 1,000 feet thick) and the greatly diversified development of the South African Permian glacial deposits." W. U.

Earth Sculpture, or the Origin of Land Forms. By JAMES GEIKIE. New York, G. P. Putnam's Sons; London, John Murray, 1898. Pp. 397, octavo, 89 illustrations, 2 plates. $2.00.

Rivers of North America: A reading lesson for students of geography and geology. By ISRAEL C. RUSSELL. New York, G. P. Putnam's Sons; London, John Murray, 1898. Pp. 327, octavo, 23 illustrations in the text and 17 plates. $2.00.

In these two works the new science of geomorphy finds its first comprehensive English expression in popular form; for, while the general and broad title of the former necessarily embraces all the principles and groups all the facts of earth sculpture, the special topic discussed by Prof. Russell, the rivers of North America, cannot be fully treated, as he himself states, without involving much more than that subject alone implies; and he is drawn easily into a brief presentation of some of the same phenomena which Dr. Geikie treats of at length, though confining himself to the region of North America.

Dr. Geikie's comprehensive subject leads to a discussion of all the agents and methods of denudation, and of all the accidental variations and as well as the usual topographic forms seen in the existing land surface of the earth, due to differences in the posé and in the hardness of the rocks of the crust when acted on by atmospheric forces. The author traces the history of a mountain, or chain of mountains, involving folding and faulting of all kinds, modified by rocks of differing hardness, through its period of ruggedness to its middle life and old age, the result being a base-level or peneplain.

The history of the peneplain is then followed further, through subsequent uplift and faulting, through long denudation and channelling by streams, through a second mountainous period, illustrated by the southern uplands and the northern highlands of Scotland, these hills being simply the results of secondary dissection of ancient plateaux. By continuance of this denudation the author shows that the whole may be again reduced to a second peneplain. "It is seldom, however, that a cycle of erosion is allowed to pass through all its stages. The study of many ancient plateaux has shown that the base-level is not infrequently disturbed, sometimes by elevation, at other times by depression."

Following this discussion of the grand round of a cycle of erosion are various chapters devoted to special topographic features and to their causes, such as hills due to faults, to igueous action, and to greater firmness and endurance of certain rocks.

The author considers glacier ice as an effective agent of erosion. "It not only abrades, rubs, smooths, and polishes, but also crushes, folds, disrupts, and displaces rock-masses, the amount of diturbance being in proportion to the reisting power of the rocks and the pressure exerted by the ice."

The work closes with a full presentation of eolian action, with illustrations, underground waters, basins, and a classification of land forms.

The author has succeeded in making an attractive grouping and presentation, in simple and plain English phrase, of the whole scheme of modern geomorphy. It is necessarily synoptical. It does not abound in illustration, but its principles are enforced as well as illustrated by reference to well-known geographic and topographic features. The field to which the author specially directs attention is Europe, and for the European student the discussions must come home with great force. A similar treatment of American phenomena of the same kind is now in order.

The book of Prof. Russell is more special, both in its intent and its execution. The philosophy of river action and the processes by which its progressive unfolding is illustrated in the degradation of the land and the final production of peneplains, are given in much detail. Indeed the detail becomes almost prolix and the descriptions tautological, when the process is presented from points of view which differ but slightly. The whole book is summarized in a single chapter (ix) which amply describes the "life history of a river." For a trained physiographist, or for an adult student who has had some training in nature's operations on the surface of the earth, this chapter is sufficient. At the same time it is elegantly written, and is even poetic in its generalized descriptions. The body of the book will serve as a guide in class-room work, or as an accompaniment to a course of lectures.

This work is strictly an American product, as it is based on American phenomena, and frequently cites American geographers. It is well illustrated with good half-tone views of actual scenes.

N. H. W.

Studies on Cambrian Faunas, No. 2, by G. F. MATTHEW. (Trans. Roy. Soc. Can. 2d ser. Vol. IV, sec. IV, p. 123.)

In this paper is described the Cambrian System in the Kennebecasis valley in New Brunswick, Canada, and its faunas.

In the first part of the paper the stratigraphy of the Cambrian rocks in this valley is set forth and there is a sketch map showing the several areas of Cambrian rocks, which are very limited. The Etcheminian series which lies between the Cambrian and Huronian (Coldbrook) in the St. John basin is wanting in this valley; and the Cambrian deposits here are much thinner than in the St. John basin.

The second part of the paper refers to the fossils found in the Cambrian rocks of the Kennebecasis valley. These are chiefly of three horizons, viz: (a) That of the Protolenus fauna of the St. John basin; (b) The Paradoxides-Dorypyge sub-fauna ("Upper Paradoxides beds" of Sweden); and (c) A fauna of the Upper Cambrian, characterized by *Anomocare stenotoides*.

In connection with the Protolenus fauna a remarkable brachiopod (already described in the Geological Magazine, London) is redescribed with further particulars in reference to some trilobites, and some new species of ostracods are described.

The sub-fauna of Paradoxides-Dorypyge is only alluded to here, it

having been described in an article in the same transactions of the preceding year.

In connection with the fauna of *A. stenotoides* several mutations of *Agnostus pisiformis* receive attention, and an interesting account is given of the parallel development of two generic forms (or what are thought to be such) from a common root-stock is shown by description and diagrammatic representation. Two plates of figures accompany the article.

MONTHLY AUTHORS' CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

Bain, H. F.

The Western Interior coal field. (Trans. Inst. of Mining Engineers, vol. 16, 26 pp., pl. 6, 1899. Read before the North of England Inst. of Mining and Mechanical Eng., Dec. 10, 1898.)

Bain, H. F.

Notes on the drift of northwestern Iowa. (Am. Geol., vol. 23, pp. 168-176, Mch. 1899.)

Barlow, A. E.

On the origin of some Archæan conglomerates. (Ottawa Naturalist, vol. 12, pp. 205-217, pls. 6-9, Feb. 1899.)

Bownocker, J. A.

A deep pre-glacial channel in western Ohio and eastern Indiana. (Am. Geol., vol. 23, pp. 178-182, pl. 6, Mch. 1899.)

Brooks, A. H. (Wolff, J. E., and)

The age of the Franklin white limestone of Sussex county, New Jersey. 18th Ann. Rept. U. S. Geol. Survey, pt. 2, pp. 425-457, pl. 83, 1898.)

Charron, A. T. (Shutt, F. T., and)

The water of the Illecilliwaet glacier. (Ottawa Naturalist, vol. 12, pp. 226-228, Feb. 1899.)

Daly, R. A.

On the optical characters of the vertical zone of amphiboles and pyroxenes; and on a new method of determining the extinction angles of these minerals by means of cleavage pieces. (Proc. Am. Acad. Arts and Sci., vol. 34, no. 12, pp. 309-323, pls. 1-3, Feb. 1899.)

*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Diller, J. S.

Crater lake, Oregon. (Ann. Rept. Smithsonian Inst. for 1897, pp. 369-379, pls. 1-16, 1898.)

Diller, J. S.

Stalactites of sand. (Science, new ser., vol. 9, pp. 371-372, Mch. 10, 1899.)

Fairchild, H. L.

Glacial waters in the Finger Lakes region of New York. (Bull. Geol. Soc. Am., vol. 10, pp. 27-68, pls. 3-9, Feb. 20, 1899.)

[Hall, James.]

The life and work of James Hall, LL.D. By H. C. Hovey. (Am. Geol., vol. 23, pp. 137-168, pls. 4-5, Mch. 1899.)

Hill, R. T.

Porto Rico. (Nat. Geog. Mag., vol. 10, pp. 93-112, Mch. 1899.)

Hovey, H. C.

The life and work of James Hall, LL.D. (Am. Geol., vol. 23, pp. 137-168, pls. 4-5, Mch. 1899.)

Johnson, C. W.

New Cretaceous fossils from an artesian well-boring at Mount Laurel, N. J. (Proc. Acad. Nat. Sci. Phila., 1898, pt. 3, pp. 461-464, 1899.)

Lambe, L. M.

On some species of Canadian Palæozoic corals. (Ottawa Naturalist, vol. 12, pp. 217-226, Feb. 1899; pp. 237-258, Mch. 1899.)

Le Conte, Joseph.

Earth-crust movements and their causes. (Ann. Rept. Smithsonian Inst. for 1896, pp. 233-244, 1898.)

Lucas, F. A.

The characters of Bison occidentalis, the fossil bison of Kansas and Alaska. (Kansas Univ. Quarterly, ser. A, vol. 8, pp. 17-18, pls. 8-9, Jan. 1899.)

Marsh, O. C.

Footprints of Jurassic dinosaurs. (Am. Jour. Sci., ser. 4, vol. 7, pp. 227-232, pl. 5, Mch. 1899.)

Matthew, G. F.

Studies on Cambrian faunas, No. 2. The Cambrian system in the Kennebecasis valley. (Trans. Royal Soc. Canada, vol. 4, sec. 4, pp. 123-153, pls. 1-2, 1898.)

Matthew, G. F.

A new Cambrian trilobite. (Bull. Nat. Hist. Soc. New Brunswick, no. 17, pp. 137-142, pl. 3, 1899.)

Moses, A. J.

An introduction to the study and experimental determination of the characters of crystals. (Continued.) (School of Mines Quarterly, vol. 20, pp. 107-142, Jan. 1899.)

Patton, H. B.

Tourmaline and tourmaline schists from Belcher hill, Colorado. (Bull. Geol. Soc. Am., vol. 10, pp. 21-26, pls. 1-2, Jan. 31, 1899.)

Phillips, W. B.

Iron making in Alabama. Second edition. (Alabama Geol. Survey, viii and 380 pp., 1898.)

Shutt, F. T., and Charron, A. T.

The water of the Illecilliwaet glacier. (Ottawa Naturalist, vol. 12, pp. 226-228, Feb. 1899.)

Smith, G. O.

The rocks of mount Rainier. (18th Ann. Rept. U. S. Geol. Survey, pt. 2, pp. 416-423, 1898.)

Stewart, Alban.

A preliminary description of the opercular and other cranial bones of Xiphactinus, Leidy. (Kansas Univ. Quarterly, ser. A. vol. 8, pp. 19-21, pls. 10-11, Jan. 1899.)

Stewart, Alban.

Pachyrhizodus minimus, a new species of fish from the Cretaceous of Kansas. (Kansas Univ. Quarterly, ser. A, vol. 8, pp. 37-38, Jan. 1899.)

Stone, G. H.

The granitic breccias of Grizzly peak, Colorado. (Am. Jour. Sci., ser. 4, vol. 7, pp. 184-186, Mch. 1899.)

Tarr, R. S.

Physical geography of New York state. Pt. VI. Lakes and swamps. (Bull. Am. Geog. Soc., vol. 31, no. 1, pp. 1-23, 1899.)

Thomson, J. P.

The physical geography of Australia. (Ann. Rept. Smithsonian Inst. for 1896, pp. 245-272, 1898.)

Turner, H. W.

The occurrence and origin of diamonds in California. (Am. Geol., vol. 23, pp. 182-191, Mch. 1899.)

Walker, T. L.

The crystal symmetry of the minerals of the mica group. (Am. Jour. Sci., ser. 4, vol 7, pp. 199-204, Mch. 1899.)

Ward, H. L.

A new Kansas meteorite. (Am. Jour. Sci., ser. 4, vol. 7, p. 233, Mch. 1899.)

Wieland, G. R.

A study of some American fossil cycads. Part I. The male flower of Cycadeoidea. (Am. Jour. Sci., ser. 4, vol. 7, pp. 219-226, pls. 2-4, Mch. 1899.)

Williston, S. W.

Some additional characters of the mosasaurs. (Kansas Univ. Quarterly, ser. A, vol. 8, pp. 39-41, pl. 12, Jan. 1899.)

Winchell, N. H.

Common zeolites of the Minnesota shore of lake Superior. (Am. Geol., vol. 23, pp. 176-177, Mch. 1899.)

Wolff, J. E., and Brooks, A. H.

The age of the Franklin white limestone of Sussex county, New Jersey. (18th Ann. Rept. U. S. Geol. Survey, pt. 2, pp. 425-457, pl. 83, 1898.)

CORRESPONDENCE.

DR. HOVEY'S REPORT OF THE LATE MEETING OF THE GEOLOGICAL SOCIETY.–The accuracy of the statement in the second paragraph on p. 99 of my report of the recent meeting of the Geological Society of America having been called in question, I have been called upon to state the authority upon which the remarks were made, as a matter of justice to all concerned. I was detained elsewhere during the reading of Messrs. McGee and Holmes' papers on "The Geology and Archæology of California" and the discussion upon them, and therefore Mr. McGee very kindly furnished me the abstract of those papers and the discussion thereon, and it was published *verbatim* in the American Geologist. This explanation is made with the consent of Mr. McGee.

E. O. HOVEY.

THE DUPLICATION OF GEOLOGIC FORMATION NAMES.—The custom of giving more or less local geographic names to geologic subdivisions has become so universal that we are even now duplicating the use of such names to a considerable extent. Geological literature is of too great bulk for the working geologist to attempt to ascertain whether or not names which he proposes to use have been preoccupied. To illustrate what the present system is leading to a few instances of some prominence will be cited.

In 1883 Hague described, in a report of the U. S. Geological Survey, the Eureka quartzyte, a subdivision of the Silurian, in the Eureka district, Nevada. In 1891, Simonds and Hopkins, in a report of the Arkansas Geological Survey, used the name Eureka shale for a supposed Devonian horizon; while in 1898 Haworth, in a report of the Kansas Geological Survey, proposes the name Eureka limestone as a subdivision of the Coal Measures.

In 1879, Peale, in the 11th Annual Report of the U. S. Geological and Geographical Survey of the Territories, employed the term Cache Valley Group for a subdivision of the Pleistocene of Utah. Becker described in 1888 the Cache Lake beds of California, in Monograph XIII of the U. S. Geological Survey, and referred them to the Tertiary. In 1896 G. M. Dawson, in a report of the Canada Geological Survey, uses the name Cache formation for a horizon of the Carboniferous to

include strata described by Selwyn in 1872 as Upper and Lower Cache Creek beds.

In 1842-46 Emmons, Vanuxem, and Mather employed the term Erie division as a subdivision of the New York system. In the Ohio Geological Survey reports, the Erie clay was used as a subdivision of the Pleistocene, and Erie shale was referred both to the Carboniferous and Devonian. In 1875 Lesley described, in a report of the Pennsylvania Geological Survey, the Erie shale, which he referred to the Silurian. In 1898 Haworth described the Erie limestone of the Coal Measures of Kansas. The above references are given merely to illustrate the confusion that is likely to arise from the use of new geographic terms, if the literature is not carefully examined for previous use.

For the past eighteen months the writer has been engaged in preparing a card catalogue of geologic formation names, during such time as could be taken from other office and field work. This catalogue has already assumed considerable proportions, and is now being consulted by those geologists who are aware that such a work is being prosecuted. While preparing the annual bibliography of geological literature for 1898 the writer has found several instances of duplication of names that have become well established in geologic nomenclature. It will probably be a year or more before this catalogue can be published, and, in the meantime, to assist in avoiding such duplication, the writer offers to furnish geologists, who will correspond with him, such information as he possesses, regarding the names which they propose to use as formation names.

U. S. Geological Survey, F. B. WEEKS.
Washington, D. C.

THE TRUTH ABOUT THE NAMPA FIGURINE.—In your issue for February (on p. 99) there are some personal references which are not only false in fact, but are in such violation of the ordinary courtesies of life, that they cannot be allowed to pass unnoticed. They occur in a report of the last meeting of the Geological Society of America, signed by Mr. E. O. Hovey. But I am informed by Mr. Hovey that the portion of the report referred to was prepared for him by Mr. W J McGee, who must, therefore, bear the responsibility for the form it has taken. In the account of the discussion concerning the Calaveras skull and other alleged prehistoric remains of the Pacific coast, occurs the following passage: "Major Powell noted the untrustworthy character of the testimony of unscientific men as to associations, instancing the Nampa figurine, alleged to have been found under the Tertiary lava-sheet in Idaho, which a well-operator sought to palm off on him as a genuine discovery, and which was afterward actually foisted on a credulous collector, and published as evidence of high human antiquity."

As thus reported, there is no mistaking the reference. It is to the figurine brought to my notice in 1889 by Mr. Charles Francis Adams, the evidence concerning which was collected by me, at his request, and published in the Proceedings of the Boston Society of Natural

History (vol. xxiv, pp. 424-450; vol. xxv, pp. 241-246) and otherwise brought to the notice of the public in numerous high-class periodicals. The evidence was also summarized in my volume on "Man and the Glacial Period" (p. 297), with supplementary discussion in the second edition (pp. xviii-xxi).

In the portion of Mr. McGee's report just quoted, there are three errors of sufficient importance to demand attention. 1st. Major Powell is made to say, that the Nampa figurine is "alleged to have been found under the Tertiary lava-sheet in Idaho."

But this is exactly the opposite of what I have alleged, and adduced evidence for believing; while Maj. Powell, whatever he may allege, has produced no evidence to prove that the lava-sheet of Nampa is Tertiary. In my first communication to the Boston Society, Mr. S. F. Emmons furnished me an extended report on the geology of the region, in which his conclusions are formulated as follows:

"I had been unable to find any fossil evidence of the age of these beds, but on other grounds had assumed that they were late Tertiary or early Quaternary. They had a younger appearance than the Pliocene deposits of Nevada, and on the other hand looked older than the Quaternary deposits of lakes Bonneville and Lahontan."

"...I must confess that at present I see no evidence which would decide whether the Nampa beds are late Tertiary or early Quaternary except that furnished by the drill hole, which if authentic would be in favor of the latter."

In my second communication to the Boston Society I presented further evidence upon this point collected during an extended personal investigation of the region in the year 1890. This I will now present more fully.

At Nampa no fossils were obtained from the well; while the strata passed through, with the exception of a thin lava-sheet near the surface, were entirely of unconsolidated material, being mostly quicksand (amounting in all to 170 feet), separated by three thin strata of clay, one of which was six inches thick, another six feet, and the third from twelve to fifteen feet. No drill was used below the lava; and so readily did the quicksand come into the pump that a great pile accumulated at the mouth of the well, far in excess of that which would come immediately from the hole. No shells or other remains of life were reported from the well until reaching a vegetable soil at the bottom, 320 feet below the surface, from which point, in connection with numerous clay balls, mixed with sand, the figurine referred to was brought up. There is nothing, therefore, in the well record at Nampa to indicate Tertiary age.

As tending to shed light upon the problem, I looked carefully for definite evidence in the surrounding country. An important discovery bearing upon the question was found at Glenn's Ferry, a railroad station upon the Snake river 85 miles east of Nampa. The station at Glenn's Ferry is 77 feet higher than that at Nampa. But, as Glenn's Ferry is on the river, and Nampa upon the plain, the general descent

of the country is much more than this. The country intervening between Nampa and Glenn's Ferry is completely enveloped with lava, and rises about 600 feet higher than either of those stations. In a ravine coming into the Snake river at Glenn's Ferry I found an extensive exposure of beds of sandstone and clay consolidated into rock underlying the lava deposit, and containing shells in great abundance. From a stratum of this sandstone about four feet thick, and more than 100 feet below the bottom of the lava, I brought home a collection of shells which I submitted to Mr. Dall, who kindly gave me the following report upon them:—

Washington, Dec. 30, 1890.

Dr. G. F. Wright.

Dear Prof. Wright.

The fossils in the rock submitted to me are: *Goniobasis taylori* Gabb (sp.), *Lithasia antiqua* Gabb, *Latia dalli* White, *Sphærium idahoensis* Meek and *S. negosum* Meek. These fossils characterize the "Idaho formation" of Cope; the rocks belong to the sedimentation of Cope's "Idaho lake" and are Pliocene, very likely Middle or later Pliocene. These rocks were synchronized at one time with King's Truckee group, formerly referred (on very insufficient evidence) to the Miocene.

Yours truly,

Wm. H. Dall.

The problem next is to determine the relation of these Pliocene deposits to the Nampa beds. The younger age of the Nampa beds is indicated, as Emmons suggested, (1) by their unconsolidated condition; for, though this may not be absolutely conclusive, it is difficult to account for the consolidation of the Glenn's Ferry deposits, so near by, except through influences of long-continued activity. (2) The elevation of the Glenn's Ferry bed above those at Nampa amounts to about 400 feet, as shown by the following comparative tables:

	Elevations at Nampa.	Elevations at Glenn's Ferry.
Railroad Station	2489	2566
Lava stratum (bottom of)	2414	2800
Bottom of well	2161	

That is, the vegetable soil at the bottom of the Nampa well is 639 feet lower than the level from which these shells at Glenn's Ferry were obtained. The evidence, therefore, that these Nampa sands and clays are younger than the Glenn's Ferry consolidated clays and sands would seem to be conclusive. The appearances indicate that the Nampa beds occur in a basin which has either been eroded out of Pliocene deposits synchronous with those occurring at Glenn's Ferry, or in a basin formed by the elevation of the Glenn's Ferry strata connected with other elevations of which we have at present no definite record. Evidently, also, the deposits at Nampa were formed by a rapid process. The quicksand beds recorded in the well were respectively of a thickness of 100 feet, 40 feet, and 30 feet.

Furthermore, not only are the presumptions against the rapid accumulations of such beds in Quaternary times removed, but a positive argument in favor of such accumulation is furnished by various general considerations.

1st. The lava-sheet extends only a few miles west of Nampa, beyond which sedimentary deposits occupy a basin extending below the junction of the Snake and Boisé rivers to the long and deep gorge of the Snake River valley across the Blue mountains about a hundred miles distant. At various points along this gorge there have been lava flows whose effect in interrupting drainage is but imperfectly understood. He would be a rash reasoner who should at present make any positive assertions in denying the effect of such agencies in producing temporary lakes in the Middle Snake River valley.

2d. In Mr. Emmons' communication to me he refers to Mr. Gilbert's investigations concerning the emptying of lake Bonneville into the Snake River region. Since then Mr. Gilbert's detailed report has been published, from which it appears that in Quaternary times a volume of water from lake Bonneville was poured into the Snake River valley, 250 miles east of Nampa and 1,975 feet above it, equal in amount to what would be carried by the Niagara river during twenty-five years' continuous flow. All this water was precipitated into Snake River valley by the bursting of a 375-foot dirt dam at Red Rock station on the Utah and Northern railroad. What the effects of this immense débacle must have been lower down in the Snake River valley we are at present unable to calculate. But the rapid production in Quaternary times of such deposits as we find in the Nampa valley above Blue mountain is perfectly credible.

There is, therefore, no definite indication of the Tertiary age of the Nampa beds; while, on the contrary, their Quaternary age is rendered by the evidence altogether probable. Those who positively assert that they are Tertiary, apparently do so on purely *a priori* grounds.

2. A second erroneous statement in Mr. McGee's report, and one which amounts to a gross libel, is that "a well-operator sought to palm off this [figurine] on him [major Powell] as a genuine discovery." Mr. McGee, who for so long a time occupied the position of literary censor in the United States Geological Survey, should know the significance of this language. In literary usage the phrase has but one meaning, namely, "to impose by fraud," a charge which should not be made except upon the best of evidence. In the present instance, this is made in reference to a well-known citizen of high standing whose character is entirely above any such imputation. If one wishes to challenge the carefulness of his observations, he is at liberty to do so after consulting the evidence which I collected and published at the time. All the evidence upon this point that major Powell may have resolves itself down to this. Major Powell was passing through the region with a party of United States senators to consider the feasibility of various irrigating schemes. His report concerning the figurine, published in the "Popular Science Monthly" in July 1893, and in a

letter to me a few days ago, correspond in general with the testimony of Mr. Kuntz, the gentleman referred to, that major Powell barely glanced at the figurine, and passed it off with a jest, saying, that he had seen many like it among the playthings of the children of the Pocatello Indians. But, so far as I know, major Powell has never presented any of these playthings for examination and comparison, and he writes to me now that he is not sure whether the thing he jested about is the same thing I am writing about. Is this the kind of evidence on which scientific men feel warranted in branding honorable gentlemen as tricksters and frauds?

3d. It is due to me that I be allowed to reply to the statement that this figurine was "actually foisted on a credulous collector [myself]." Here again it is to be observed, that Mr. McGee is supposed to know the meaning of the word "foist" (which reflects again on the character of Mr. Kurtz), namely, "to work in by a trick." I beg leave, therefore, to restate some points in the evidence which render this charge preposterous.

(1) The direct evidence was first brought to the attention of the eminent men (Mr. G. M. Cummings, the general manager, and Charles Francis Adams, president of the Union Pacific Railroad) associated with Mr. Kurtz in his work under circumstances that entirely preclude any attempt at deception. But not to linger upon this point, which will be fully evident to any one who reads my original report, we notice that

(2) The circumstantial evidence in confirmation of the direct testimony is ample. After being sent to me, the figurine was submitted to professor F. W. Putnam, who at once called attention to the accumulation upon its surface in various places of patches of oxide of iron, especially, under the right arm, where quartz grains of sand were cemented together by this oxide. Furthermore, in connection with this figurine there came up from the bottom of the well numerous concretionary clay balls, some of them more than three inches in diameter. The material in these is identical with that in the figurine, and they were coated upon the outside with a similar accumulation of iron oxide. On submitting this material to F. F. Jewett, professor of chemistry in Oberlin College, he attempted every experiment known to him to produce a corresponding iron oxide upon the clay of the balls, and found it impossible to do so by any processes of simple heating, and only approximately by heating the clay when coated with a solution of iron chloride. The only possibility, therefore, of its having been produced upon the spot in recent time was by the agency of an expert chemist, and no such person was in the region. Indeed the theory that such a person made the figurine is scarcely more probable than that an angel from heaven did it. Professor Jewett's conclusion, therefore, was that the accumulations of oxide of iron upon the figurine could not be accounted for "except by supposing it to have been the result of the slow decomposition of substances containing iron, in its immediate vicinity." The figurine was an ancient relic of some sort.

An additional word should be said, also, respecting the possibility of the figurine's coming from such a depth without injury. Inquiry into the conditions readily shows that this is entirely possible. As already said, the strata below the capping of lava near the top were unconsolidated, and no drill was used below the lava, except to cut through the clay strata. An iron pipe six inches in diameter was driven down with sections screwed on to the top to give the required length. The material inclosed was brought to the surface by a sand-pump, which consisted of a tube about eight feet long, with a valve in the bottom three inches and a half in diameter opening up. This let the quicksand and water and occasionally clay balls between two and three inches in diameter into the pump, and the whole was drawn up to the surface, and emptied out at the top. As already said, a great amount of quicksand was sucked in towards the bottom from outside the hole; so that there was a considerable area near the bottom from which to derive the specimen, which, as already said, is only an inch and a half long, and could more easily get into the pump through a three-inch-and-a-half valve than could the three inch clay balls which came up in abundance from near the same horizon.

If, after examining the evidence, the men of science choose to call me credulous, I must endure the obloquy. But, I trust, at any rate that the pages of our scientific periodicals will not be hereafter disfigured by charging gross fraud upon an honorable and well-known gentleman upon such slight basis of evidence as has been done in the case of Mr. Kurtz.

Oberlin, March 10, 1899. G. FREDERICK WRIGHT.

PERSONAL AND SCIENTIFIC NEWS.

LAPHAM IN BRONZE. A bronze bust of the late I. A. Lapham was placed in the public museum at Milwaukee, Mar. 7, presented by John Marr. Addresses were made by Dr. E. W. Bartlett, president of the Board of Trustees, L. W. Halsey, representing the mayor of the city, and Mr. John Johnston, the last being printed in full in the *Evening Wisconsin.* It was the 88th anniversary of Lapham's birth, and Mr. Johnston gave a review of his life and character.

DR. L. L. HUBBARD has resigned the position of state geologist of Michigan, and has accepted the position of general manager of a mining company having a large tract of land on Keweenaw point. The primary cause of this action is the constant opposition of the State board of auditors to the work of the survey by refusing to publish its reports. The state printer has had in hand the printing of Vol. VI, for

more than two years. Recently the survey has been active in the southern peninsula, especially in the Saginaw valley where much exploration is being carried on for coal and other economic products. Volume VI of the survey reports will be issued in a few months. It contains large contributions by Dr. A. C. Lane.

MR. GILBERT, OF THE U. S. GEOL. SURVEY, lectured on "The Story of Niagara," Mar. 2, at the Teachers' College of Columbia University, New York.

THE PRESENT ADDRESS OF DR. M. E. WADSWORTH, one of our editors, is Marquette, Mich.

FRANK SPRINGER, well known as paleontologist in association with Wachsmuth in the great work lately published by the Museum of Comparative Zoology, Cambridge, on *Crinoids*, is a resident of Las Vegas, New Mexico, and has been largely instrumental in the establishment of the New Mexico Normal University at that place. This institution was lately dedicated, and Mr. Springer, as president of the board of regents, pronounced the dedicatory address. He was followed by Pres. Edgar L. Hewett at the head of the University. Amongst the speakers at the banquet was Pres. C. L. Herrick of Albuquerque.

MR. HJALMAR LUNDBOHM, of the geological survey of Sweden, is in the United States making a comparative study of the iron ore deposits, particularly in the lake Superior region. Mr. Lundbohm has devoted much study to the economic geology of Sweden and has been especially interested in the large deposits of magnetite at Gellivare and Kürunavaara in northern Sweden. He is known personally to a large number of American geologists, as he participated in the western excursion of the International Congress of Geologists, 1891, and in the lake Superior excursion of the Geological Society of America, 1893.

MR. JOHN H. SEARS, of Salem, Mass., is engaged in compiling the physiography and geology of Essex county, Mass., as far as yet determined. His field work during the coming season will embrace the fossiliferous sediments of Rowley and Newbury, and part of the glacial drift of the county.

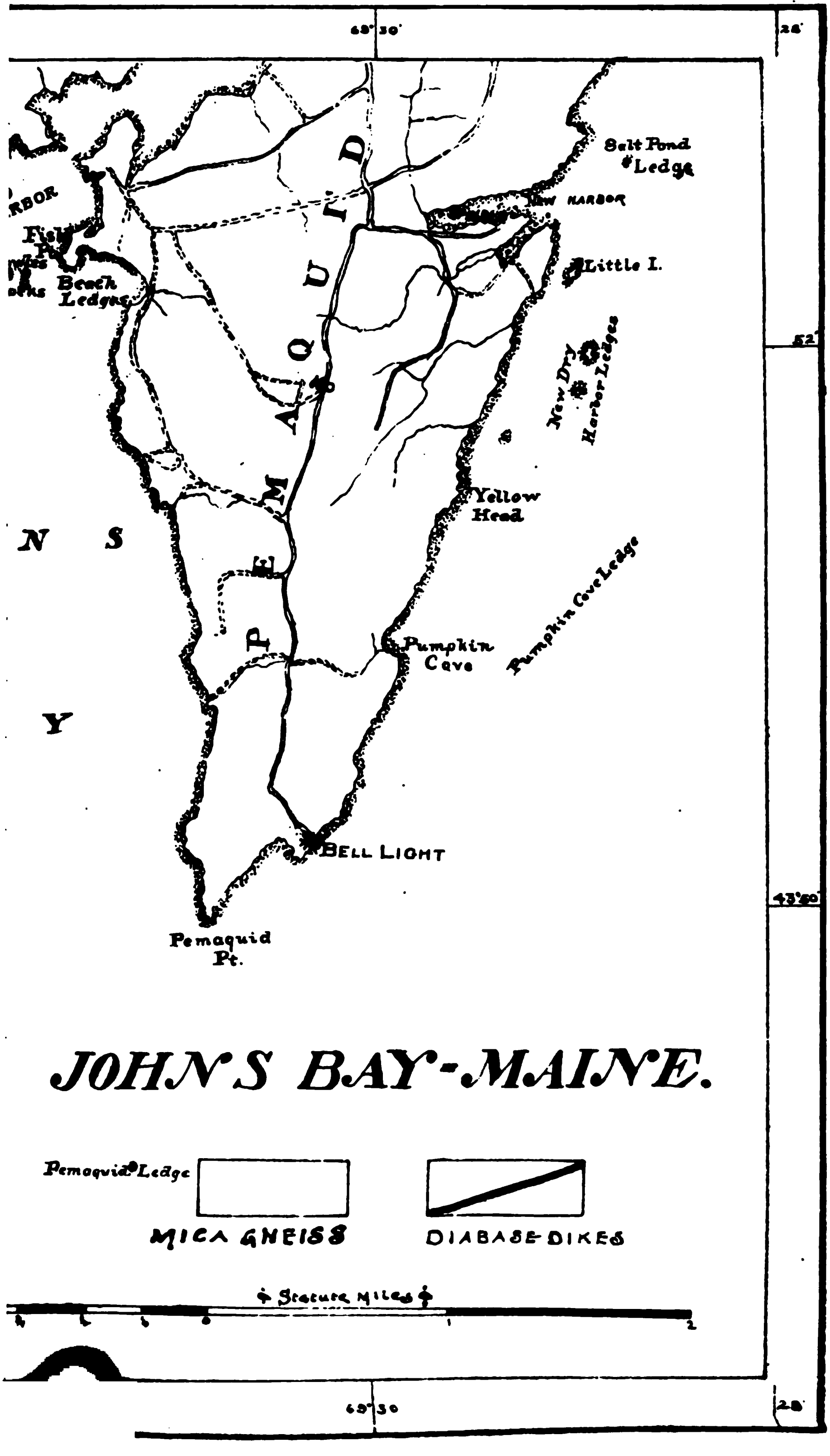
THE PROFESSORS OF GEOLOGY IN THE University of California and in Stanford University have organized a geological club, to be called the "Cordilleran Geological Club." It is intended to include all the geologists of the Pacific and adjacent states, and its object is by occasional meetings to stimulate geological work. Whether it shall remain an independent organization or shall be affiliated with any other scientific body is left for future decision. (*Science*.)

HENRY ALLEYNE NICHOLSON, since 1882 Regius professor of natural history in the University of Aberdeen, died on Jan. 19, 1899. He was born Sept. 11, 1844, in Penrith. Early in his career he studied medicine and in 1871 left England for Canada to assume the chair of natural history in the University of Toronto. While here he carried on investigations for the Ontario government on the fauna dredged up from lake Ontario, and he also described the fossil corals and polyzoans of Ohio, the report being published in the second volume of the "Palæontology of Ohio." During his residence in Canada the first edition of his now noted "Manual of Palæontology" was issued. In 1874 Prof. Nicholson returned to Great Britain. His chief interest lay along the lines of field geology and invertebrate paleontology, but it is in the latter line that his chief work was done, he being one of the noted paleontologists of this century. His ability as a teacher and lecturer was preeminent, his sympathy with fellow workers was marked, and his capacity for work was enormous. Prof. J. G. Hinde has given a sketch of Prof. Nicholson's life, with a portrait, in the current number (March) of the "Geological Magazine."

MAJ. JED HOTCHKISS, OF STAUNTON, VA., died Jan. 17, aged 70. He was the author of a geological work entitled "The Virginias," which consists essentially of a republication of some of the older official reports of Messrs. Rogers on the geology of that state.

PROF. OLIVER MARCY, long professor of geology at Northwestern University, Evanston, and for many years dean, died at his home March 19, aged 79.

PROF. O. C. MARSH, Yale University, died of pneumonia at New Haven, March 18, aged 68.


69° 30'
28'
52'
43° 50'
Salt Pond Ledge
NEW HARBOR
Little I.
New Dry Harbor Ledges
PEMAQUID
N S
Y
Beach Ledges
Yellow Head
Pumpkin Cove Ledge
Pumpkin Cove
BELL LIGHT
Pemaquid Pt.
JOHNS BAY-MAINE.
Pemaquid Ledge
MICA GNEISS
DIABASE-DIKES
Statute Miles
1
2
69° 30
28'

DIABASE DIKE IN GNEISS. THRUMCAP ISLAND, MAINE

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ON SOME DIKES IN THE VICINITY OF JOHNS BAY, MAINE.

By F. BASCOM, Bryn Mawr, Pa.

(Plates VIII, IX, X and XI.)

Introduction.—The repeated occurrence of trap dikes along the coast of Maine has already been noted and their characters at several localities have received detailed descriptions. The literature of the subject is given in a recent article in this magazine.*

To the localities listed by Mr. Lord may be added Rutherford's island and Thrumbcap island. These islands, lying between Johns bay and the mouth of the Damariscotta river, are about five miles east of Boothbay and forty miles northeast of Portland. Rutherford's island is separated from the mainland by a narrow channel spanned by a bridge. Thrumbcap island, three-fourths of a mile south of the southern extremity of Rutherford's island, forms with that island the continuation of the narrow foreland lying between the Damariscotta river and Johns bay.

The fiord-like character of the seaboard is impressive in this region as elsewhere on the coast of Maine and the manifold and varied indentations of the shore-line furnish scenery unsurpassed in picturesque quality. While the coast is rugged the relief of the land is not great. The highest point on Rutherford's island is one hundred and fifty feet above sea-level while the adjacent mainland reaches the hight of 210

*E. C. E. Lord: On the Dikes in the vicinity of Portland, Maine. The American Geologist, vol. XXII, No. 6, Dec., 1898, p. 335.

feet only on a single summit west of Rutherford's island on Linekin's neck.

Formation of Island.—Glacial deposits are represented by stray boulders only. The soil is therefore thin and bare rock may be seen everywhere. Rutherford's island is composed, like the mainland within the area of the map, (see plate VIII) of a folded mica gneiss. In lithological character, this formation varies from a quartz biotite schist, with little or no feldspar, of medium grain and dark color, to a light colored coarse-grained gneiss. (Plate IX.)

Acid Dikes.—The gneiss is crowded with pegmatyte veins and intrusions. These veins usually lie parallel to the strike and to the cleavage planes of the gneiss. They are extremely irregular in width, expanding abruptly into rounded knobs around which the enveloping rock bends—or disappearing in attenuated bands of almost pure quartz. Pegmatitic lenses parallel to cleavage and strike repeatedly occur. Veins of pure quartz also abound. There are also present pegmatytes of a more dike-like character. These are more often parallel to the joint planes and transverse to cleavage and strike. The southern end of Hay island shows such an acid dike, as do also some of the Thread-of-life ledges. These dike-like bodies are alike in their extremely acid characters and in their coarse texture.

Cutting the pegmatytes indiscriminately are basic dikes whose intrusive character is unmistakable. These dikes vary in width from two hundred feet to a few inches, but in no case is the grain of their crystallization comparable in coarseness to that of the acid rocks, nor is the nature of their occurrence similar.

The pegmatytes demand a somewhat different explanation for their formation. This may be found in the predication of a water-saturated magma.* The great size of some of the intrusives, the absence of banding or comb-structure peculiar to veins of purely aqueous deposit, and the order of crystallization indicate an igneous origin. While the grain of the crystallization and the passage into purely siliceous veins demands the presence of water. The parent mass may under-

* W. O. Crosby and M. L. Fuller: The Origin of Pegmatite. Technology Quarterly, Vol. IX, No. 4, Dec., 1896, pp. 326-356.

lie the gneiss. Genuine aqueous veins are represented by the purely quartzose bands.

Gneiss.—The strike of the gneiss is north and south, varying from 5° to 17° east of north. The general north and south structure of the land is pronounced and the eastern coast-line closely parallels the strike of the rock. The gneiss possesses two prominent sets of transverse joints, of which one strikes N. 55°-80° W., and the other N. 50° E. On the west shore, the sea has in several instances entered the land along the northeast joint planes, forming narrow passages in which the tide reverberates at high water. A notable instance of this on Squirrel island is known as the "devils hallway." The passage has since its formation been elevated above the reach of the sea. The gneiss pitches gently to the southwest and is compressed into folds in an east and west direction.

The pronounced planes are those of cleavage. The strike of the cleavage is usually parallel to the strike of the stratification and the dip of the cleavage is 45° N. W. This is sometimes coincident with and sometimes transverse to the stratification dip. The stratification planes are obscure but at various localities on the eastern border of the island can be seen gently (40°) dipping N. W. and on the western side dipping S. E. with many minor folds.

Age of Gneiss.—Hitchcock places all the coastal gneiss, lying between Portland and the Penobscot river, in the middle Laurentian. The sedimentary character of the gneiss of Rutherford's island and the adjacent mainland can scarcely be questioned. Under the more recent classification of Pre-Cambrian rocks, this formation will probably fall into the Algonkian division of the geological column.

Basic Dikes.—The basic dike on Rutherford's island, of which a petrographical study was made, outcrops at the head of Christmas cove. Striking N. 85° E., it crosses the island at Foster's point and comes into veiw again on the west bank of the Damariscotta river. At this point it disappears beneath the gneiss. It possesses a uniform width of approximately two hundred feet.

There are two sets of joints of which one strikes N. 25° W. and the other N. 75° E. The material of this dike is a medium

grained, greenish grey massive rock with a conchoidal fracture. It weathers a reddish brown with a slightly roughened surface owing to the decay of the olivine.

Specimens, which were subsequently sectioned, were taken from exposures at four different localities. Each of these localities is represented by three specimens, of which two are from the borders of the dike and one from the centre. These slides show the rock to be an olivine diabase of a normal character. Plagioclase, pyroxene, and olivine constitute the chief mass of the rock, while the structure is typically ophitic.

The two chief constituents, pyroxene and plagioclase, are about equally abundant. The pyroxene is augite with the usual characters: a pinkish grey, non-pleochroic mineral with the characteristic biréfringence, cleavage and twinning (parallel to 010). It always occurs in allotriomorphic areas which are often so collected in groups as to give a porphyritic cast to the rock. Near the edge of the dike where the mass of the rock becomes aphanitic these areas become more decidedly phenocrystal. Sometimes large areas show a curved cleavage and undulatory extinction. The augite contains no inclusions and is comparatively fresh but shows some slight alteration to chlorite.

The other ferromagnesian constituent is distinguished from augite by its colorlessness and its idiomorphic and columnar character. Besides the longitudinal cleavage (010) there is irregularly developed a conspicuous transverse parting parallel to the base. The index of refraction is high, but not equal to that of the augite. Most of the columnar sections show the emergence of an axis while the other sections show high double refraction. The extinction is parallel except in unsymmetrical sections. This olivine so closely resembles the colorless or white pyroxene noted in the diabase of the New Haven region, that only the results of optical tests convinced the writer that the constituent was olivine and not a variety of pyroxene. Considering the readiness with which olivine yields to alteration, the mineral is very fresh, though more altered than the augite. The alteration product is a yellow serpentine.

Plagioclase appears in two generations: as a net work of intergrown lath-shaped crystals of varying lengths and

DIABASE DIKES IN GNEISS. THRUMBCAP ISLAND, MAINE. SHOWING FINER CRYSTALLIZATION ON THE EDGES.

DIABASE DIKE IN GNEISS. THRUMBCAP ISLAND, MAINE. SHOWING HORIZONTAL COLUMNAR STRUCTURE.

DIABASE DIKE IN GNEISS. THRUMBCAP ISLAND, MAINE. SHOWING HORIZONTAL COLUMNAR STRUCTURE.

magnetite. Augite and olivine play a somewhat more important role as phenocrysts than does the labradorite. The olivine which in some sections is more abundant than the augite, is always idiomorphic and is sometimes completely serpentinized. Even in these narrow dikes there is a difference in grain, perceptible in the hand specimen, between the selvage and centre of the dike (Plate X). In the gneiss in immediate contact with the dike occur hornblende, biotite and titanite while the mass of the rock is plagioclase and quartz.

On the beach in front of Pemaquid Fort, there is exposed a dike of considerable width and hence of coarser grain than the dikes of Rutherford's and Thrumbcap islands, but not altogether dissimilar in constitution and structure. It has a lighter color, due to the predominence of the feldspathic constituent. The predominating feldspar, in this rock seems to be andesine ($Ab_5 An_3$). Pericline twinning is a prominent feature and the angle of the pericline bands on 010, with the basal cleavage is 0°. The maximum extinction angle of the albite bands is between 15° and 20°. The feldspar occurs as broadly lath-shaped crystals.

The augite is much more altered than in the other dikes. The alteration product is chlorite, which has, in some cases, completely replaced the augite. Olivine is not present. Biotite occurs as a minor constituent. There is considerable idiomorphic magnetite and some apatite. The structure is coarsely ophitic. The rock, as a whole, is less fresh than is the material of the other dikes.

It is impossible to make any statement as to the age of this dike or of the Rutherford and Thrumbcap diabases. In the latter case the microscope shows the material to be as fresh and unaltered as is the Newark diabase of the Connecticut valley.

A PLEA FOR THE POPULAR EXPOSITION OF LITHOLOGY FOR MUSEUM PURPOSES.

By L. P. GRATACAP, New York.

In public museums, enclosing the double purpose of instructing the people as well as meeting scientific requirements, the problems of presentation are frequently difficult. They can, however, quite usually, be solved by exacting some concessions from both the public and the student. The former consents to overlook technical precision and terminology, and find consolation in the beauties of the exhibit, and the latter averts his eye from temporizing expedients of language and arrangement, content to enjoy the amplitude and variety of the collections. But in lithology it is very hard to interest the public at all by any superficial attraction in the specimens, and the scientific exposition in conjunction with them is too apt to leave in its mind only resentment and impatience. Yet lithology demands a place in our museums and as it has been recognized abroad must be somehow thrust upon the average visitor—a compound of ingenuous curiosity and self-respecting intelligence—here as well.

In considering some possible system for the achievement of this purpose the following scheme is suggested, which can, in its specific details, be much varied. The subject can be broken up or divided under seven heads. 1. Idea of Rock; 2. Terms; 3. Physical Condition; 4. Lithologic Processes; 5. Classification; 6. Distribution; 7. Life History; 8. Geologic Occurrence.

I. *Idea of Rock.*

The average man has a poor or incomplete conception of the scientific implications of a rock, and while he apprehends clearly enough the geographical extent of rocks, perhaps their physical properties, he fails to realize their mineral nature, and utterly their classification and relations. The Idea of a Rock can be expressed by, *first*, the mechanical analysis of a rock, the separation of granite into mica, quartz, and feldspar, the unbroken fragment of granite, and the separated piles of grains of its mineral elements; the separation of doleryte into augite and labradorite, with accessories of hornblende, quartz, magnetite, olivine, etc., and the peeling apart of a sandstone into its constituent grains. In all such physical

demonstrations the essential elements should be sharply indicated, and the provisional or accidental or sporadic nature of the accessories also clearly stated, the whole illustrated by some homely analogy, as cement being typically a mixture of sand and lime in which brick dust, or clay, or glass, or pebbles, might be mingled.

The Idea of Rock *secondly*, as not necessarily a compound of minerals, but an extension in mass and area of a single mineral, can be expressed in contrasted specimens of calcite crystals and dolomite crystals with blocks of marble and limestone, gypsum in crystals with large fragments of alabaster or rock plaster, serpentine hand specimens with serpentine masses, the whole enforced by printed explanations and photographs of marble and gypsum quarries.

The Idea of Rock, *thirdly*, can be expressed by tables of physical constants, and by statistics of industry in the use of rock. Tables of physical constants are too numerous to demand specification. A sheet of them well printed could helpfully be placed in a section of the cases of exhibition. Examples chosen from Merrill or the ninth census, may be here briefly quoted.

Locality.	*Strength per sq. in.*	*Wt. per c ft.*	*Sp.Gr.*
Biotite Granite—Niantic, Conn.	9,550 lbs.	162.5 lbs.	2.6
Hornblende Granite—E. St. Cloud, Minn.	28,000 lbs.	163.1 lbs.	2.609
Gneiss—Madison Ave., N. Y.	11,250 lbs.	182.5 lbs.	2.92
Trap—Taylor's Falls, Minn.	26,250 lbs.	187.5 lbs.	3.00
Limestone—Bardstown, Ky.	16,250 lbs.	166.9 lbs.	2.67
Marble—Lee, Mass.	22,860 lbs.		
Marble—Stillwater, Minn.	25,000 lbs.	172.6 lbs.	2.76
Sandstone, Jordan, Minn.	3,750 lbs.	113.1 lbs.	1.82
Sandstone, Near Fort Snelling, Minn.	20,000 lbs.	138.8 lbs.	2.22

The contrasted strength or co-efficient of resistance to pressure between rocks in their bedding and on edge could be introduced in the preceding tables. Then might follow a sheet of chemical compositions. That, by photographs of buildings, with description of the stone employed in their construction, making the selection as broad as possible, including volcanic as well as sedimentary rocks. Then some statistics of industry in stones taken from census reports or mineral resources of the United States. By such manifold data the dawning conception of rock grows outward into a complete compass of its various aspects.

The Idea of Rock, *fourthly*, can be expressed by contrasted states of aggregation as dust, clay, sand, gravel, with lava, slate, sandstone, conglomerate, for it is a plain violation of sense to call the first rocks. They are not. They are material on the way to rock or derived from rock. They are what they are called, and form beds, sheets, banks, beaches, layers, mounds, etc., but from the point of view of lithology they are not rock.

The Idea of Rock, *fifthly*, can be enforced by examples of the variation of the same rock as quartzose, micaceous, hornblendic, granite, coarse and fine grained granite, grained and glassy basalts, phenocrystalline and obsidian liparytes, etc.

The Idea of Rock, *sixthly*, can be further enlarged by thin sections, viewed through hand glasses, and by colored or uncolored drawings, subjects being selected which are the widest opposites as andesytes and granites, sandstones and quartz porphyry.

These six aspects of rock will bring the visitor into complete contact with a many sided conception of rock, and the next steps will neither be abrupt nor unexpected in the development of his appreciation of lithology.

II. *Terms.*

It is unnecessary to introduce many definitions, but enough to fix by a name the features of rock already seen, and others which succeed. The following terms seem adequately comprehensive:

stratified,	illustrated	by	banded limestone, gneiss.
massive,	"	"	serpentine.
granular	"	"	Berea sandstone.
crystalline	"	"	granite, trachyte.
schistose	"	"	mica schist.
concretionary	"	"	oolyte.
pegmatitic	"	"	graphic granite.
conglomeratic	"	"	pudding stone.
brecciated	"	"	Taconic marble.
porphyritic	"	"	quartz porphyry, verde antique.
clastic	"	"	sandstone.
glassy	"	"	obsidian.
vesicular	"	"	pumice.

In other words, I would group under terms definitions of the megascopic features of rocks. Many more could be introduced, but in a popular exposition terms, thinly separated by scientific differentiations, should be avoided. Inasmuch as from beginning to end the scheme of rock presentation involves practically definitions, under terms those only pertaining to unaided ocular recognition are included. In the next step forward the intelligent visitor is led to consider in Physical Condition the microscopic structure of rocks.

III. *Physical Condition.*

Under physical conditions it seems desirable to gather a series of examples illustrating the microscopic features of rocks. A thin section enlarged by a low power objective, with label and colored or uncolored drawing, will fully meet the requirements. Such features or phases of rock structure should be chosen as will, in igneous rocks, demonstrate the progressive changes of crystalline state from glassy through devitrification to holocrystalline structure with clean intelligible illustrations of idio- and allotriomorphism. The lesson to be taught is the imminent tendency to crystallization in molten mineral masses, a tendency only checked by sudden cooling, while the examples shown can be so selected as to most simply show interference of crystals, ground mass and the development of essential and necessary minerals. Besides these basic conditions, perlitic, lithiophysic, spherulitic texture can be illustrated. In clastic (sedimentary chemical) rocks the instruction conveyed presents the differing stages of aggregation of the cemented or semi-crystallized contents, as in limestone, the varying composition of sandstones, and the change of clay into argillyte. In metamorphic rocks, rock sections of gneiss and marbles, and roofing slates, quartzyte, etc., would reveal simply their ultimate structure, the process involved in their creation being considered in the next section. Each group [igneous, clastic (sedimentary) metamorphic] of examples should be preceded by a definition of the group. This, on account of similar or identical definitions, following in later sections of the display, involves repetition. But repetition is not to be shunned or feared. In disclosing to the popular mind the principles, facts and conceptions of lithology, repetition in a

relevant and necessary way is desirable. The reiteration of an idea in any course of instruction imbeds it more fixedly and deeply in the student's thought. The repetition should be accordant with itself as a matter of course.

IV. *Lithologic Processes.*

The succeeding step to those which have imprinted on the mind of the visitor a fairly comprehensive realization of rock features, is the treatment of those general processes by which rocks, as we know them, have been formed. These processes, conveniently for the purpose herein designed to be attained, may be considered as three-fold, viz.: *vulcanism*, *metamorphism*, *sedimentation*, and *consolidation*, including in this last chemical or organic action.

Vulcanism is first to be defined, and examples for its two formal types given, the pericentric and the regional, including under the latter all forms of dykes. As illustrating the former such an infallible and luminous example as Vesuvius could be chosen with a drawing of sections of its lava flows showing superimposition, and an imaginary dissection of its basement. The plugged and dissected cone of Kammerbühl, in Bohemia, the pumice cone at Campo Bianco, in the island of Lipari and the eroded and reduced Auvergne region are instructive examples. Illustrations of regional vulcanism are abundant, and the Palisades of New Jersey, Snake river dalles, Obsidian cliff of the Yellowstone, Henry mountains are typical. Photographs, drawings, can here be wisely, if not too lavishly, used.

Metamorphic action is less easy to typify and explain. Its essential preconceptions are formed in chemistry and crystallography. It means molecular mobility producing chemical compounds and crystalline tissue, under the influence of heat and hydro-dynamic agencies. How can such difficult assumption be popularized? The most intelligible symbols are the baking of bread and the vitrification of porcelain, the induration of brick with its development of color and the formation of refractory kernels of silicates. These are still very approximate, are, in a way, misleading. The facts of regional and contact metamorphism can be given, hand specimens showing metamorphism in slates exhibited and the impression deepened that heat and pressure not only bake but crystallize, and that

by heat and pressure in the presence of water minerals are formed. Perhaps fair illustrations could be transcribed from experimental synthesis and mechanical observations, as W. Spring's determination of conchoidal fracture and crystalline texture of dry pulverized chalk, after seventeen years in a screw press under very high pressure, while extracts could be made from Becker's account (now in some particulars doubtful) of the process of metamorphism observed by him in the metamorphic rocks of California. (U. S. Geol. Surv. Monograph No. XIII.)

After the idea has been dwelt upon, examples of possible sediments, muds, etc., and schists, slates, or marbles resulting from them by metamorphism can be introduced.

Sedimentation, consolidation, chemical precipitation are more simple. A direct appeal to the senses can here be made. The cylindrical jar, with its layers of sand, gravel, clay, etc., in a series under the water, illustrates sedimentation, the gravel formed into a conglomerate by carbonate of lime or iron oxide cementing its pebbles (many morainal banks will show this process of rock making) illustrates consolidation, and the lime deposit from water as the linings of "hard cake" in boilers, the shell formed organically in water, and the growing stalactite and stalagmite, illustrate chemical precipitation.

V. *Classification.*

Broadly, rocks can be grouped for popular instruction under fragmental and crystalline, and crystalline under igneous and metamorphic, and the series arranged in the order of fragmental, metamorphic, igneous. Under fragmental breccias, conglomerates, sandstones, limestones, slate would be exhibited. Under metamorphic schists and marble, and under the igneous, the acid to basic series as devised and recommended by Van Hise, Weed, Turner, Cross and Diller, and admirably summarized by Merrill in "Rocks, Rock-Weathering and Soils."

VI. *Distribution.*

Under distribution maps showing the areas occupied by sedimentary, metamorphic, and igneous rocks are recommended. An elaboration of this section can easily be devised by sets of rocks from different parts of the country or of the

world, whereby, especially in igneous rocks, variations and contrasts can be instructively indicated, as for example the hypersthene belt of eruptives along the Rocky mountains, and the more generally augitic and hornblendic series in the east, the consolidated limestones of the Mississippi basin, as contrasted with the crystalline marbles of the Appalachians, and the association of the crystalline schists with axes of elevation and folding, overthrust and contraction. Distribution could be more rigorously treated in an exhibition of bathysmic as well as superficial extension, the older lower igneous rocks usually presenting acid features as succeeded by more basic overlying lava flows. Again local peculiarities admit of much interesting treatment as the foyəyte dyke in New Jersey, and the rare occurrence of phonolytes in the United States. For popular use, however, broad, easily grasped features are to be preferred.

The lesson is more easily learned, is generally more forcible, and is better remembered.

VII. *Life History.*

The life history of a rock can be made difficult or simple. Its embryology, so to speak, can be introduced, its phylogeny and its disintegration. We can point out the constituents of a rock, show from what sort of a general mass, magma or sediment these constituents have originated, illustrate phases in its construction and then pass from its typical form to those changes which, whether by uralitization or decomposition, mark its later or last stages. More usually such a study of its life history would mean, with a rock, a portrayal of its dissolution, and rock weathering could be well illustrated by a direct transference to the cabinet, of the words and examples of Prof. Merrill's book.

VIII. *Geological Occurrence.*

This section practically is a selection of geological zones, depicted by representative rocks amongst which fossiliferous rocks would be included. Such zones are preferably to be made broad ones, as Archæan, Laurentian (Huronian), Algonkian, Silurian, Devonian, Carboniferous, Jura Trias, Cretaceous, Tertiary, Recent. Two series, one from Europe and one from America, could be profitably compared.

PRELIMINARY NOTES ON THE SURFACE GEOLOGY OF THE YUKON TERRITORY.

By Otto Nordenskjöld, Upsala, Sweden.

During the summer of 1898, I made an expedition to the gold-fields in the Klondike district in the Yukon Territory. I was accompanied by a Swedish geologist, Dr. Frithiof Anderson, and by others who still remain in that quarter. The collections we made being thus likely to be added to, and time not having been found for a complete study of those already at hand, a full account of the observations taken cannot be given until later. These notes, therefore, are restricted to a few observations made on our journey to and fro between the Alaska coast and Dawson City.

The Yukon river, or more correctly speaking the chief branch of that river, the Lewes river, commences its course, as is known, only about 11 miles from Dyea Inlet, the innermost bay of the Lynn canal, while it is possible from the head of lake Linderman, 18 miles from the sea-coast, to cover the whole distance to Klondike by steamer with only two quite short breaks. Hence this route is the most convenient one to the gold-fields and I availed myself of it both on my journey there and back. I had, however, but few opportunities of getting away any distance from the ordinary channel of traffic.

The geology of the district passed through has been described by several explorers, especially worthy of mention being Dawson, McConnell, Russell and Spurr.* Their investigations show, in the first place, that the mountain lakes, still of considerable size, forming a broad belt on the northern side of the coast chain of mountains were of still greater extent formerly, ancient shore-lines being found 400 and up to 600 feet (at lake Lebarge, according to Russell) above the present surface, while terraces formed of silty deposits rise to about

*The chief works on the geology of the district are:

G. M. Dawson: Report on an exploration in the Yukon District, N. W. T. Geol. Surv. Can., Ann. Rep., 1887, Part B.

R. G. McConnell: Rep. of an Expl. in the Yukon and Mackenzie Basins, N. W. T. Geol. Surv. Can., Ann. Rep., Vol. IV, (1888-1889), Part D.

I. C. Russell: Notes on the Surface Geology of Alaska. (Bull. Geol. Soc. Am. Vol. I, p. 99.)

J. E. Spurr: Geology of the Yukon Gold District, Alaska. (U. S. Geol. Surv., 18th Ann. Rep., Part III 1898).

150 feet above the river just above lake Lebarge. The only point of disagreement has been as to whether these deposits and shore lines were formed by arms of the sea or by inland lakes.

It is further evident from the accounts spoken of that the whole country in the neighborhood of the coast chain was once covered with ice, inasmuch as glacial furrows have been observed as far north as the mouth of the Hotalingua river. North of that a light-coloured clayey earth is exposed in the bed of the Yukon valley, unstratified or only obscurely stratified, containing pebbles and boulders, some of them striated, and described as a true till or glacial boulder-clay, although both Dawson and Russell maintain that it might have been formed without direct communication with land-ice. This deposit is found up to the vicinity of the Five Finger rapids, but beyond that point traces of ice-action cease, and it seems to be a fully accepted fact that the whole of the northern section of the Yukon Territory and Alaska was never covered with ice. Spurr alone brings out certain peculiar features in the topography of the valleys, which he connects with the local glaciers still to be found in their upper parts in the early summer.

In what follows an attempt is made to divide up the country into sections as it presents itself to a traveler from the seacoast through the Yukon valley to the mouth of the Klondike river.

1. *The Region of the Fjords and the Western Pacific Mountain Slopes.*

Observations that I made here I intend to publish elsewhere along with those of similar nature from other parts. As is well known the most characteristic feature in the topography of the coast of British Columbia is a system of channels running parrallel to the limit of the continent, just as is the case in western Patagonia. But there are also genuine fjords that run transverse to the general direction and which as a rule continue their course, here just as in Patagonia, right through the outer island-chain. The Lynn canal forms a sort of intermediary between these two. Dyea inlet, the innermost arm of the canal, is 11 miles long and one wide; it forms, as it were, a separate fjord, the bed of which lies 170 fathoms below the bar at its mouth. On the other hand lakes are only rarely found

in this district, above the head of the fjords. The Dyea inlet has a continuation in the form of a valley filled with sand, the topography of which does not differ in any noticeable degree from that of the inlet. This sand becomes as we proceed upwards gravel of increasing coarseness. Beyond the shore-line it descends rapidly to the bottom of the fjord (50 fathoms in about ½ mile). The same is the case in the majority of the fjords.

About ten miles above the head of the inlet the valley just spoken of divides, the chief branch coming to an end somewhat abruptly in a steep wall, through which the river has cut its way down into a canyon, several hundreds of feet deep, the walls of which are often perpendicular. Similar terrace-like walls in the continuation of the valleys are not uncommon; by large rivers they are cut through, but small creeks often form waterfalls over them, pursuing above a meandering course. The trail is here on the terrace and does not reach the river again until some miles further up at Sheep camp; here the river valley has a beautiful U-shape, with a rocky bottom everywhere visible. The course of the valley is suddenly stopped by a precipitous wall of rock, nearly 800 feet high, over which passes the trail of the Chilkoot pass.

2. *The Region of the Mountain Chain and the Inland Lakes.*

The mountain-chain itself here is not particularly lofty, compared with what is found farther west, but, as might be expected considering the dampness of the climate and the abundance of glaciers, it is exceedingly wild and broken in outline with high peaks and narrow ridges often surrounding deep amphitheatric valleys. Compared with the ocean side the slope towards the north is very moderate. This circumstance is evidenced in the fact of the more extensive valleys being occupied in their upperparts for a width of more than 100 miles almost entirely by lakes, which may be divided into at least three clearly distinct groups. Uppermost, almost immediately below the hight of the passes (both at Chilkoot pass and at White pass), there is a series of comparatively small mountain tarns of an irregular, elongated shape and situated approximately at the same level; their shores, frequently consisting of smooth rock, points to their having been excavated by ice. I

was not able to take any soundings to ascertain their depth. Out of the lowest of these lakes, Deep lake, the river flows for almost three miles through a canyon with vertical walls of rock, and is impassable in the summer time. These canyons, that are found on both sides of the pass, are very interesting. I think it presumable that they were formed subsequent to the glacial age and consequently they show how long a time must have elapsed even at this hight above the sea since this region was covered by ice. The severe decay that some of the different kinds of rock in the sides of the valley show points in the same direction. The origin of the canyons is perhaps connected with an unequal and extreme uplift of the central portions of the mountain-chain.

At the foot of the terrace-wall passed by the canyon is situated lake Linderman, the first of the extensive system of large lakes that occupy a number of parallel valleys at a hight of 2,150 to 2,170 feet above the sea, joined by cross valleys also filled with water. The lakes are quite fjord-like and are enclosed by steep walls of rock on an average 3000 feet high. They are moreover very deep. I took a number of soundings, though not as a rule in the centre of the lakes; they consequently may be taken to show too low results. In lake Linderman at a mile from the southernmost end, the depth was 130 feet, in the middle 160 feet, and at a quarter of a mile from the foot of the lake it was 80 feet. In lake Bennett only two soundings were taken. The greatest depth discovered was about 200 feet. In the S. W. arm of lake Tagish I registered a depth of 80 feet, but the depth at the entrance to the arm called Windy bay is probably much greater. Lake Marsh and lake Nares are filled with sediment and are everywhere shallow; the greatest depth discovered in the former was 40 feet.

At lake Linderman the above-mentioned and elsewhere often described terraces are first seen. The plainest of them, consisting of gravel and silt, is exactly 50 feet above the surface of the lake, as measured by the barometer. Above it however there are others almost equally clearly marked, the topmost one being 125 feet above the lake. At a still greater elevation, 280 feet above the lake, is the beginning and lowest part of the mountainous terrace-plateau intersected by the above mentioned canyon. The rock is here as a

rule exposed: gravel is seldom seen and nowhere are there deposits that might be supposed to contain organic remains. The upper rock-terraces are here indistinct, but lower down, for instance opposite the entrance to Windy bay, they appear very well; they are estimated to be from 800 to 1,000 feet above the lake here.

That water actually reached that hight is proved by the plain gravel terraces lying on the east side of the river below lake Tagish. Their substance is certainly but little stratified, being in places almost moraine-like, but there can be no doubt that it has been subject to the influence of waves and the terrace itself is very clearly marked. Its elevation above the police station at Tagish was determined at 970 feet, that is about 3,120 feet above the sea, and it may possibly at other points be still higher. The White pass being only about 2,600 feet in elevation it is presumable that the water found its outlet there to the south at that period. It is moreover evident that the terraces reach their best development at a hight of about 2,500-2,700 feet, and on the road between lake Bennett and the White pass one can observe that the interior plateau is almost on a level with the pass.

Observations calculated to show the character of the water that helped to form these terraces are not forthcoming and this question will not probably be solved otherwise than by an examination of a much larger district; or still better if it were possible to discover some deposits still containing remains of Diatomaceæ or other organisms. On the other hand it is probable that the typical silt deposits, seeing they are nowhere situated more than 200 feet above the surface of the existing lakes, were formed in fresh water, seeing that their geographical extent is so limited.

Professor Cleve has kindly examined some specimens from this formation with the purpose of discovering the presence of Diatomaceæ, and states as follows:

1. Specimens of silt with layers of clay (from Miles canyon and from a place 10 miles below Big Salmon river) contain no microorganism at all.

2. Clay with pebbles from a terrace-line about 900 feet above the police station at Tagish: A single specimen of *Stauroneis phœnicenteron* var. *amphilepta* Ehb. (freshwater), that may however be of secondary origin.

3. A mud-like layer from the uppermost part of the silt, a few miles below the mouth of the Takheena river (about 50-75 feet above the level of the river) contains very rarely specimens of *Pinnularia viridis* (Nitzch.), and *Stauroneis phœnicenteron*, var. *amphilepta* Ehb. (fresh-water).

4. Mud, probably younger than the silt formation, from the Yukon valley at the Tagish police station, contains the following freshwater forms: *Cymbella ehrenbergii* Kütz.; *C. gastroides* Kütz; *C. turgida* Greg.; *Cymatopleura elliptica* W. Sm.; *Epithemia turgida* Kütz.; *Hentzschia amphioxus* Gmn.; *Navicula ludlowiana* A. Schu.; *Neidium affine* (Ehb.); *Pinnularia major* Kütz.; *P. borealis* Ehb.; *P. viridis* v. *distinguenda* Cl.; *Pleurosigma attenuatum* (Kütz.); *Stauroneis phœnicenteron* v. *amphilepta* Ehb.

The almost entire absence of organisms in the different layers of silt, with a few freshwater forms in the upper parts, and a richer flora in the youngest deposits seem to confirm the opinion of a deposition in glacial lakes rather than in fjords with salt or brackish water.

3. *The District of the Border Lakes.*

These lakes preserve their resemblance to fjords as far as up to the north end of lake Bennett. At about the same latitude the Windy bay of lake Tagish, the Atlin lake and several other large lakes not yet mapped out come to an end. The Taku Arm alone, after being united with the first two sheets of water mentioned by means of a considerable cross valley, continues as a lake for some miles further. then turning into the chief valley of the Lewes river. The topographical valley in which lake Bennett is situated continues northwards. In order to arrive at a knowledge of the mode of formation of these lakes a careful study of that depression through which the Watson river now runs would be of great importance.

There are but few lakes of any size north of the latitude mentioned. The first of them is lake Marsh. which. as stated above, is comparatively broad and shallow and is immediately surrounded by wooded lowlands. It may from this circumstance be said almost to form a group of itself. From that point the river pursues its course for 20 miles through a valley that for the most part is not particularly marked. and then another lake is reached, the last and at the same time the largest in this stretch. Its name is lake Lebarge. [illegible]

again, a true mountain lake with rocky shores, though very unlike the upper lakes. Near the head of this lake the last mountain peaks and ridges are seen; lower down all the hights to an elevation of 2,000 feet above the valley are rounded and at least as regards the lower ones polished in a manner that can scarcely have arisen otherwise than by glacial erosion, a supposition which is not contradicted by some of the hights, sugar-loaf in shape, consisting of masses of limestone. Glacial striæ from this part have been described by several explorers, and Russell was led to assume by their fresh appearance that the glacial period could not have been very distant in date. The lake itself is of a considerable depth. At one point I found a depth of 360 feet, while at its center it is probably deeper still.

To explain the origin of these lakes resort can be had to four theories: they were either excavated by ice, or arose through faults in the rocks, or were dammed by unequal folding, or by deposition of morainic material. The last theory is untenable seeing no moraines of the requisite extent have been found either in the valley of the Lewes river or in the Ogilvie valley, the topographical continuation of lake Lebarge. I made an excursion up the last mentioned and hitherto unvisited valley for some 20 miles, finding everywhere the same white silt that occurs also so plentifully in the river valley. The idea that this silt could under present topographical circumstances have dammed up such a large lake is inconceivable. Nor does the dislocation theory commend itself, at any rate as regards the majority of the lakes, for then a straighter course in the valleys would have been probable, and greater differences in the rocks adjacent on either side of them and in their beds as compared with the hights around. A combination of the two remaining theories strikes me as most probable. It is to be presumed that the glacial erosion was excessive, but if it had hollowed out all these basins we should have expected to find traces of it in the shape of much more extensive moraines than those actually found. Plication and subsidence in conjunction with ice-loading, possibly united with dislocation to some extent, would therefore seem to be the principal agents in the production of these valleys. Russell seems to advocate a similar theory.

4. *The Region of Transition.* (Lake Lebarge to Fort Selkirk.)

The topography of the Yukon territory exerts its chief influence upon us through its relations to the phenomena of the glacial period. Nowhere in the world is it possible to study to such advantage as here the changes that land ice with its attendant glaciers brings about. The coast chain was presumably at one time completely covered with ice; all even the most lofty plateaus are dotted over with erratic blocks and kame-like formations are also found. Only the valleys, however, are rounded; all the summits rose above the ice for a sufficiently long time to assume the characteristic broken and erosive form that belongs to all mountain chains that are exposed to the influence of great variations of temperature. All round lake Marsh, on the other hand, and still more so round lake Lebarge all the summits are rounded and polished by the ice, which possessed considerable thickness but was, nevertheless, in the main body confined to the valleys and which subsequently retreated from the district rapidly. The district immediately to the north presents features of great interest. The mountains as elsewhere are bare, while their details are rounded in "roches moutonnées" form. Deeply decayed rocks are only to be found in well protected narrow valleys.

North of the Big Salmon river it is only the lower slopes of the mountains that preserve this glaciated form, the upper slopes being broken and sharply outlined; the boundary between these zones that without doubt marks the utmost hight the ice attained gets lower and lower. In the neighborhood of the Nordenskjold river it is about 200 feet high; north of the Rink rapids no hills rounded by ice are met with. The mountains are covered with gravel that has arisen from atmospheric causes, while where the actual face of the rock projects it is often very much broken into pointed pinnacles, probably in part attributable to the wind having removed the products of atmospheric decay.

It is evident that a glacier of diminishing thickness towards the north passed through this valley and came to an end somewhere north of the Five Finger rapids. We have already mentioned the boulder-clay, lying with a covering of sand and gravel in the valley-bed in this district. Its appearance is far

from being like that of an ordinary ground moraine, and it is scarcely surprising that Russell pointed out the possibility of its having been formed in some other way. Its geographical extent, however, proves that it was formed in the vicinity of the edge of the tongue of the glacier.

5. *The Northern Unglaciered Region.*

I did not visit the districts north and west of the Klondike river and cannot, therefore, pronounce as to whether still further division into zones can be made. Compared with what is seen to the south however in the above described district the region acquires a very pronounced character after one leaves the Pelly river behind. It may be studied most conveniently in the gold district lying between the Klondike and Indian rivers. All the hills are rounded and have no trace of sharp outlines either on a large or a small scale; they are divided off from one another by valleys with rounded sides varying in depth according to the size of the watercourses flowing through them. Solid rock is only occasionally met with on the loftiest water divides and in the frequently steep slopes down to the larger rivers. In other places the rock foundation is everywhere covered with vegetation beneath which there is a thick saprolite of rock decayed in situ. This is so soft that it may be cut by a knife and the marked transition from one to another of the different coloured layers of graphite, chlorite, and biotite schist, as well as the undecayed quartz veins, can still be discerned.

That this decayed crust cannot have arisen exclusively since the glacial period may undoubtedly be considered a certainty and hence we have a direct and decisive proof that this part cannot have been covered with glaciers or land-ice. It occurs, however, also in the deepest parts of the valleys, which for reasons we shall presently give are not very old; and if we are not willing to assume that the later portion of the Tertiary period or some part of the Quaternary had a much warmer climate than the present we have here a proof that a pronounced rock decay can take place amid climatic conditions not very dissimilar from those now prevailing immediately south of the polar circle in Yukon. The heads of the valleys are often of a regular amphitheatrical shape and there

are often to be found in the early summer in the upper forks of the larger valleys veritable though small local glaciers just like those described by Spurr from the Forty Mile district. Occasionally, moreover, a blue clay containing angular stones is to be found in the larger valleys; this may be due to a sort of moraine attendant on the local glaciers. Otherwise all moraine accumulations are wanting.

In the beds of these valleys it is that the gold is lodged. In another place* I have given an account of its occurrence and confine myself here to the mere mention of the fact that the greatest part of it lies in the lowest layer of the river gravel and in the top 5-8 feet of the disintegrated and partly decayed bed-rock. Along with the gold there are found numerous mammoth remains,—among others whole tusks which can scarcely have been secondarily washed out of the older layers. Seeing the whole mass is frozen hard all the year round and that the gold is only found in small quantities in the recent river gravel, we are bound to assume that the main body of the gold was washed clear and deposited during a time when the mammoth was still in existence in these regions, presumably during the Pliocene or Pleistocene epoch. As in most of the valleys no foreign blocks are to be found at all, the metal must come from the circumjacent rock, which is a schist distinguished for its very muscovite-like mica. In the whole territory where this rock is found the rivers are exceedingly rich in gold. The rock contains continuous veins as well as short, irregular, contorted and shredded lenticular bodies of quartz; and seeing the larger quartz boulders practically never contain gold in a free state it seems most probable that the gold originates from the smaller bodies, perhaps enriched in shear zones. Practically no free gold has yet been discovered in the rich district in the surrounding rock.

Actual plateaus do not occur in this region though rounded ridges are common; they are as a rule of almost the same hight above the sea,—nearly 3,000 feet. On the top of these I never saw any gravel that showed evidence of rolling; and it is an open question as to whether these ridges form the surviving remains of a "pene-plain" or of a plateau originating from ma-

*In a paper sent to the editors of the "Zeitschrift für praktische Geologie," Berlin.

tine denudation. An answer might perhaps be arrived at by studying its boundary in the direction of the lofty pointed mountain chain that hems in this district north of the Klondike river. The geology and topography of these projecting mountain-chains, the glacial phenomena and the shore-lines that may exist there, are some of the most important problems requiring investigation in this otherwise extremely interesting district, which is likely to attract a large share of attention from geologists in the immediate future.

THE MISSOURIAN SERIES OF THE CARBONIFEROUS.

By CHARLES R. KEYES, Des Moines, Iowa.

INTRODUCTORY.

The Carboniferous rocks of the Missouri River region were brought to notice more than half a century ago. A generation ago they were the subject of one of the most bitter controversies that ever occurred in the history of American geology. For a period of two decades all geological consideration of the region has been neglected. Only of late has interest in it revived.

The almost total lack, from the very beginning, of exact and connected data relating to the geology of the Missouri river has necessitated recently a reconsideration of the whole subject. The result has been to gain a complete and connected idea of the succession of formations, and an arrangement of them that is eminently satisfactory as well as readily applicable to the whole region. This district comprises large portions of southeastern Nebraska, southwestern Iowa, northwestern Missouri, eastern Kansas, Indian Territory and eastern Oklahoma.

The term Missourian was originally proposed* for the major part of the great sequence of limestones and shales, that has long been known, in the western part of the Mississippi valley especially, as the "upper coal measures." Subsequently†

*Iowa Geol. Surv., Vol. II, p. 85, 1893.

†American Geologist, Vol. XVIII, p. 25, 1896.

the subdivision to which the title was applied was regarded as constituting one of the four great series making up the Carboniferous. The name was selected for the reason that the Missouri river cut through, from top to bottom, the entire succession of strata, and traversed the formation for a distance of more than 500 miles.

Previous to obtaining the data for the exact correlation of the various parts of the Missourian series, the typical localities of the principal subdivisions of the Mississippian series, or lower Carboniferous,* and of the Des Moines series,† or productive coal measures, were visited and the relations of the different formations carefully made out. A similar consideration of the Missourian series, or the third of the four major numbers of the Carboniferous, is herewith given.

The recent detailed examinations of the Missouri river exposures of the Carboniferous had, as its fundamental incentive, the establishment of a standard section to which all of the formations composing the Missourian series, in all parts of the latter's geographic extent, could be conveniently referred. The selection of this, rather than any other, line for the typical section of the series was influenced by a number of factors: first, the natural conditions were unusually favorable for correlating the various vertical sections not visibly connected; second, there was furnished a reliable basis for future operations in the region; third, as most geological work is conducted more or less independently in the several states, a plan for uniformity of methods and nomenclature was provided; fourth, the foundations were laid for a more general consideration of the geology of the region than had hitherto been attempted; fifth, the cross-section was as nearly transverse to the belt as it is possible to obtain; and sixth, a number of deep-well records furnished means of checking the extension of the formations below the river level.

HISTORICAL CONSIDERATIONS.

From the time when Nicollet‡ made his explorations of the hydrographical basin of the Mississippi, in 1841, during which he descended the Missouri river

*Bul. Geol. Soc. America, Vol. III, pp. 283-300, 1892.

†Proc. Iowa Acad. Sci., Vol. IV, pp. 22-25, 1897.

‡Sen. Doc. 26th Cong., 2nd Sess., Vol. V, pt. ii, No. 237, 1841.

from the mouth of the Big Sioux river above Sioux City, to St. Louis, down to the present time many geological notices have appeared in regard to the geological formations bordering the great stream. Most of these references, however, have been incidental or fragmentary, some alluding to one part of the section and some to another. Of all of these Broadhead's* section is the most complete. This purports to give a connected succession for a much greater distance than any other. Though described in too much detail to be applicable over any considerable area, it is, in its main features, essentially correct so far as it goes. His correlations of other exposures with the Missouri river sections are, however, somewhat faulty.

Nicollet, Owen, de Verneuil, and others believed that the formations exposed on the Missouri river were the Mountain limestones of the Mississippi, that were brought to the surface on the opposite side of a broad syncline the lower portion of which contained the productive coal measures of Iowa and Missouri. Swallow† appears to have been the first to discover that the Missouri river rocks were above and not beneath the principal coal-bearing formation of the region.

Marcou‡, Meek§, and White and many others who have visited the Missouri river have given only isolated, uncorrelated sections. Swallow¶ and Broadhead** have constructed from the various exposures a generalized vertical section; and recently Bennett†† has, on the Kansas side of the stream, corroborated many of the earlier observations of Broadhead on the Missouri side, though only in a very general way. Of late, Prosser‡‡ has recorded some of his observations made in southeastern Nebraska, dealing particularly with the uppermost part of the series.

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*Geol. Surv. Missouri Iron Ores and Coal Fields, pt. ii, pp. 80-133, [illegible]

†Missouri Geol. Surv., 1st and 2nd Ann. Repts., p. [illegible] 1855

‡[illegible] Soc. Geol. France [illegible]

§U. S. Geol. Surv. Nebraska, [illegible]

[illegible]

¶[illegible]

**[illegible]

††[illegible]

‡‡[illegible]

Heretofore no attempt has been made to harmonize the numerous isolated exposures or to make complete the exact sequence of strata from the base to the top of the series.

The earliest investigations in the region did not attempt to estimate the vertical extent of the various strata that compose the Missourian series. Those who entered the district under the auspices of the several states bordering the Missouri river all considered the beds, as a whole, very much too thin. Usually these estimates were only one-fourth to one-sixth the real values, bringing the total down to 300 and even 200 feet. Nearly every one of these writers manifestly confused the different limestones, not recognizing that there existed several very distinct formations very much alike in general characters. This is notably the case with Swallow, Hawn, White, and their associates. Since Broadhead's work of 1872, there has been a general tendency to greatly over-value the real thickness of the series. Nearly every one of these later writers, who has given the matter consideration, placed the figures at five to ten times as great as the earlier calculations. , Without exception these estimates also have been based upon insufficient observations. They have in no case extended over the whole field.

The Missourian Series.

Relations to the Other Carboniferous Series. Since the Carboniferous rocks of the Mississippi valley first came into notice, over half a century ago, various classifications have been suggested. As recently stated little detailed investigation was done having for its special object an arrangement for the whole region. In consequence the subdivisions that were proposed, differed widely in the different states and even in different parts of the same state.

Of late, the lower Carboniferous in all its minor parts has been satisfactorily correlated over all of the northern Interior basin. The lower coal measures have also been subdivided in a way that enables the various members to be widely recognized. The so-called Permian has received attention. The major sub-divisions of the Carboniferous of the region are now pretty well defined.

Distinguishing Characters. In all of the six principal

features of geographic distribution, topographic expression, lithologic nature, stratigraphic delimitation, biologic definition, and economic content, which go to characterize and contrast geological formations, the Missourian series is clearly set off from all associated strata.

Its areal range and geological position are intermediate between the Des Moines series on the one side and the Oklahoman on the other.

The topographic expression of the area occupied by the Missourian strata is of a wholly different type from that of the Des Moines or that of the Oklahoman. The latter are soft rocks and the general aspect of the country is a lowland plain of faint relief. In the case of the Missourian area there is an alternation of hard and soft beds; the strata are slightly inclined westward and the whole region is bevelled off. The new cycle of erosion that has begun has not worn down the rocks equally. The hard members are left in relief. A series of escarpments, nearly parallel to one another is formed. These face eastward; that is, the steep side is in that direction, and the gentler backslope is in the opposite direction. The latter soon merge into the lowland areas between the ridges, worn out on the soft rocks. It is essentially the step and platform topography, or, as it is more gracefully termed, cuesta relief.

In lithological characters the Missourian beds are chiefly limestones and calcareous shales. They thus differ from those of the Des Moines series, which are largely argillaceous or sandy shales, and from those of the Oklahoman, which are likewise near-shore deposits. Next to the Mississippian, the Missourian beds are the most strictly marine deposits of all the Carboniferous of the region. The fauna is also strictly maritime.

In economic content the almost total absence of coal puts the Missourian series in marked contrast with the Des Moines.

Base of the Missourian. The lower limiting horizon of the Missourian series is the bottom of the Bethany limestone. In all features it is one of the most pronounced lines of demarkation in the whole Carboniferous system as represented in the continental interior. The limestone itself is the most important above the Mississippian. Below it, through all the Des Moines

series, shales predominate and the lithological contrast to the Missourian is very marked. Even in deep drill-holes put down through Missourian strata the change at this level is readily noted.

The topographic features presented by the Bethany limestone sharply indicate the passage from one series to the other. A noteable eastward facing escarpment everywhere limits the western surface boundary of the Des Moines belt. This ridge is so prominent a feature of relief that it is disclosed in all the profiles of the railroads crossing it. In the northern part of its course the heavy drift deposits are unable to hide it. Further southward beyond the limits of glaciation a remarkable belt of rugged country is produced.

The basal member is highly fossiliferous. From below the change in faunal features is striking, and attracts at once the notice of even the casual observer.

Top of the Missourian Series. The Cottonwood limestone has been taken as the crowning number of the Missourian. The closing episode in the deposition of the strictly marine beds of the region should be regarded somewhat lower down. The change need not be made here. The formation is a buff, massive limestone, composed largely of shells of Fusulina. Its geographic range is wide, extending from Nebraska, through central Kansas, into Oklahoma. Forming a well-marked horizon it is of great practical use in locating the limits of the series. All the watercourses crossing the belt disclose the Cottonwood rock in vertical cliffs. Being a good building stone the course of the limestone at the surface is marked by a long line of quarries.

Stages of the Missourian Series.

General Vertical Sections. Heretofore it has been impossible to get a connected section of the Missourian beds. Practically no attempt has been made to differentiate all of the formations that go to make up the series, though various names have been given to certain exposures. The nomenclature of these is followed as far as possible. As represented along the Missouri river eleven well marked subdivisions have been recently made out. With their respective thicknesses, they are as follows:

		Feet.
11.	Cottonwood limestone	10
10.	Atchison shales	500
9.	Forbes limestone	25
8.	Platte shales	105
7.	Plattsmouth limestones	30
6.	Lawrence shales	265
5.	Plattsburg limestones	35
4.	Parkville shales	75
3.	Iola limestone	30
2.	Thayer shales	50
1.	Bethany limestones	75

Bethany Limestones. The name Bethany, which is applied to the formation now regarded as the basal member of the Missourian series, was first used by Broadhead, in 1862, in a somewhat more limited sense. As originally proposed the title referred to the main body of the limestones. Its distribution is given on the Missouri and Kansas maps, it following the eastern border of the series. Its relief features and other essential characters have been already described. The formation is a three-fold one, composed of distinct heavy limestones, separated from one another by a few feet of shale. The formation becomes very much thicker to the south.

Thayer Shales. This name was used, in essentially the same connection as it is now, by Broadhead, in 1884. By him the shales "of Thayer" were fully described and a detailed section given. Haworth in 1896 rechristened the formation, using the same name and having the same typical locality, but without knowing of Broadhead's earlier work.

When not obscured by drift deposits the Thayer shales form a marked lowland belt of country lying between the Bethany ridge and the Iola escarpment. These soft rocks have a marked effect upon the drainage courses of the region. The shales have a few limestone bands intercalated that carry peculiar and characteristic fossils. Locally, the blue, argillaceous portions are also remarkable for the faunas they contain. The wonderful forms of crinoids, in an almost perfect state of preservation, that have been lately described from the "upper coal measures" of Kansas City, come from the upper part of these shales. In southern Kansas a thin coal seam is present, and associated with it, are abundant plant remains.

The thickness of the shales increases both to the north and

to the south of Kansas City. At that point it is not over 40 feet. Northward they are more than double this thickness; and southward over 200 feet.

Iola Limestone. The first attempt to designate the formation under consideration was by Haworth in 1894. As in the case of the Bethany limestone, the Iola forms a notable escarpment running nearly parallel to the first named. It is a single bed of limestone, made up of rather thin layers, but having no shale bands. It withstands weathering well, and hence imparts ruggedness to the local relief. Beginning at St. Joseph, where it is very thin, and fails entirely to the north, it gradually increases in thickness until, in southern Kansas, it attains a vertical measurement of over 100 feet. Its texture is compact and color buff. Comparatively few fossils occur in it.

Parkville Shales. The name Parkville is intended to cover all those beds, consisting chiefly of shale, that lie between the Iola and Plattsburg limestones. They are typically developed in the neighborhood of the town of Parkville, on the Missouri river, in Platte county, Missouri. Thus far they have proved rather unfossiliferous. Several thin bands of limestone occur, one of which in Kansas is said to assume sufficient importance to secure the special name, Carlyle, and to subdivide the formation into three members, of which the upper is called the Lane shale.

According to deep-well records the Parkville and Thayer shales come together northward, and finally merge not far from St. Joseph. This is brought about by the fading out of the Iola limestone. In the Missouri river section the Parkville shales nowhere attain a thickness of more than 75 feet; farther southward, in Kansas, they increase to 100 feet or more.

Plattsburg Limestones. As early as 1872, Broadhead called the main limestone layers of this formation the "Plattsburg group," giving as typical localities, Plattsburg, Parksville and Waldron, Missouri. In Kansas these limestones have recently been named in different places the Garnett, the Burlington and the Toronto. The formation is 35 to 40 feet in thickness. It is composed of two principal limestones, which are separated by a few feet of shale, the latter sometimes attaining a measurement of a dozen feet or more. The upper member is a gray limestone, which is especially characterized by the fossil

"Syntrialasma hemiplicata," and is known as the Syntrialasma zone. The lower member is a buff limestone.

Lawrence Shales. The name was first applied by Haworth, in 1894, to the greater part of the beds occupying the interval between what is believed to be the Plattsburg and Plattsmouth formations. It was afterwards extended to all the strata between the two limestones. The maximum thickness is at least 300 feet and in southern Kansas probably greater. Several limestone beds occur in it. Two have received in Kansas special designations, the Strawn and the Ottawa. On the Missouri river minor subdivisions are easily recognized over a wide area. The upper member is known as the Andrew shale, the median one the Iatan limestone, and the lower the Weston shale. These subdivisions are traceable for a long distance into Kansas. The exact relation of the limestone to the Strawn is not known, yet it is not believed to be the same. On the Kansas river a thin coal seam occurs in the upper part of the Lawrence.

Plattsmouth Limestone. The relations of the Carboniferous beds exposed in Nebraska to those farther down the Missouri river have never been considered. The rocks of the northern district have had a singular history. The typical section of the Plattsmouth early attracted attention. Owen visited the locality more than fifty years ago. From the same limestone, at Bellevue a few miles away, he collected numbers of characteristic fossils. He was of the opinion that all of the rocks exposed along this part of the Missouri river belonged to the Carboniferous limestone series (Mississippian). They are so colored on his map. The marked dip to the southward, which he observed below the mouth of the Platte river, probably was the chief factor that lead him to believe that the Coal Measures were deposited in a shallow saucer-shaped basin of which the opposite rim was near the Mississippi river.

Although he mistook the limestone exposed at Bellevue to be the same as that at Parkville and Weston (Plattsburg limestone), Swallow considered all of these formations to lie above the productive coal measures, and he called them the Upper Coal series or Upper Coal Measures. During the same year (1855) there appeared a geological map of the United States, by Marcou, in which these formations of the Missouri river

were colored as New Red sandstone, or Triassic. The later English edition of the map, accompanying his Geology of North America, has the same coloration.

During the next decade numerous visits were made to the Nebraska localities. In 1857, Hayden gave out the results of his observations. He refers the rocks, exposed south of the Platte river, to the Carboniferous or Coal Measures. From observations made during a brief sojourn in the region Marcou and Capellini were lead to place the Plattsmouth beds in the Lower Dyas, or Permian. A year later, Meek pointed out, in a special paper, the fact that the rocks in question belonged without doubt to the Coal Measures, and not to any younger formation. Geinitz, who described the fossils collected by Marcou in Nebraska, only incidentally mentions the limestone at Plattsmouth, remarking that it was probably below the Nebraska City section, and belonged to the "obern Kolenkalk."

Although so many references had been made to the formation, no specific name was given to the limestone prior to 1872, when Meek considered the Plattsmouth section in considerable detail. He grouped about 200 feet of strata below the heavy limestone above the Plattsmouth into the "Platte division." This included all of the shales, now known to be not more than 100 feet in thickness, exposed in the vicinity of the Platte river, the limestone now called the Plattsmouth, and the few feet of shales beneath the latter, that are exposed at the steamboat landing. As the greater part of the "division" is a well defined formation comprising almost entirely of shales, the term Platte has been reserved for that subdivision. Meek, however, in the same memoir calls the fossiliferous limestones the "Plattsmouth beds." By this name they have since become widely known. For this reason it is believed that the limestone should be continued to be known by the name of a locality which has become classic in American geology.

From Plattsmouth the beds dip southward, and those exposed at that place soon disappear below the river level. Swallow seems to be the only one who has suggested any connection between these beds and those farther southward between St. Joseph and Kansas City. He says, incidentally, that a certain limestone of his upper coal series is exposed at Bellevue, the mouth of the Platte river, near St. Joseph and elsewhere

southward. This statement is manifestly little more than a happy guess. It was only very recently demonstrated beyond doubt that the limestone so well exposed at the first mentioned locality and the one in the top of the bluffs at St. Joseph are the same. As Swallow, in the same sentence referred to, made three other and very distinct limestones continuous with this one it is safe to conclude that he merely surmised the connection between the limestones of all four localities.

In the recent geological work done in Kansas there has come to be widely recognized through the eastern part of the state a conspicuous limestone which has been named, after the hill on which the Kansas State University stands, the Oread limestone. It appears to be identical with the Plattsmouth limestone of Nebraska and Iowa. The name Oread was first used by Haworth, in 1894. At a subsequent date it was extended so as to include two limestones separated by 20 feet of shale. Its wide extent in Kansas was recognized, and it was correlated with the Plattsburg limestone of Missouri, a view now known to be erroneous. Subsequently Bennett traced the Oread north from Leavenworth nearly to Iowa Point, and regarded it as probably equivalent to Broadhead's No. 150. This is now correlated with the Plattsmouth.

The thickness of the Plattsmouth limestone may be placed at about 30 feet.

Platte Shales. In the Nebraska sections along the Missouri river, there appear above the Plattsmouth limestone over 100 feet of shales to which the term Platte may be appropriately applied. The name was first used by Meek, who called the rocks exposed from Omaha to Nebraska City the "Platte division, from its development in the vicinity of the mouth of the Platte river, where the various outcrops seem to exhibit a thickness between 200 and 300 feet." This embraces all of the shales from the upper limestone,—the first important limestone (Forbes limestone, or bed B of Meek's section) above the Plattsmouth,—the latter, and some 25 feet of shales below. The Plattsmouth limestone forming a well defined member by itself the name Platte is retained for the major part of the "division," or the shales.

The Platte shales are also well exposed in Missouri and Kansas between St. Joseph and Forest City. They extend up

the Nodaway river 25 to 30 miles; and they are also well displayed on the Platte river in Missouri, at and north of Savanah. On the Kansas river between Lawrence and Topeka other good sections occur. On the Missouri river above Forest City they dip beneath the water-level and for a distance of over 50 miles do not again rise.

Forbes Limestone. In the Missourian series there is one limestone of special importance between the Plattsmouth and the summit Cottonwood formation. This has been called the Forbes formation from the town of Forbes, in Holt county, Missouri, in the vicinity of which excellent exposures occur. The stratum has been referred to many times in the literature of the region, but with no special designation. The fact that it forms an important stratigraphical horizon over a large area, in four states, warrants its recognition as one of the guiding beds for correlation. Its correlation with the limestones of the Kansas river section, in the vicinity of Topeka has not been suggested. The thickness of the Forbes is about 25 feet.

Atchison Shales. In the most recent papers the name Wabaunsee has been used in connection with the formation under consideration. The latter name is derived from one of the counties in central Kansas where the formation is well exposed. The designation is that of Prosser for a sequence of shales that occupy the interval between the Cottonwood limestone and the Osage coal. It was subsequently made to include a few feet of shale below the last named horizon and to extend down to the Forbes limestone. The equivalent of the latter in central Kansas may be the Topeka limestone.

There seems to have been another name that has been used in nearly the same sense as Prosser originally used Wabaunsee This will probably have to be substituted for his name. As early as 1873 Broadhead designated the uppermost beds of the Upper Coal Measures as exposed in northwest Missouri, as the "Atchison County Group". Subsequently he refers often to them. His descriptions of the lithological and faunal characters, though widely scattered, are very complete. Regarding the stratigraphic position of the formation it reached from the summit of the Missouri section—now known to be about 75 feet below the Cottonwood limestone—almost to the Nodaway coal which is nearly on the same horizon with the Osage coal

of central Kansas. The Atchison beds thus have very nearly the same limits assigned to them as a quarter of a century later Prosser proposed for the Wabaunsee. They occupy over four-fifths of the interval that the Wabaunsee occupies in the vicinity of the northwest corner of Missouri. For this reason Atchison appears to be the only name that can be legitimately used for the shales between the Forbes and Cottonwood limestones.

The Atchison shales are 500 feet thick on the Missouri river. Near the base is at least one seam of coal of sufficient thickness for profitable mining. This is the Nodaway coal, which has a very considerable extent in northwestern Missouri and southwestern Iowa. The Aspinwall coal seam in southeastern Kansas is probably a part of the same stratum.

These extensive shales impart certain peculiarities to the topography of the area occupied by the Nodaway coal that are not noted elsewhere in the Missouri region. The soft rocks have permitted a moderately uniform plain to be worn out. In Missouri Marbut has designated the plain the Maryville lowland, thus recognizing it as one of the important relief features of that state. The shales, moreover, occupy the bottom of the Brownville syncline. Owing to the attitude of the strata, their softness, and the peculiarities of drainage in the region, by which the lowland plain has been formed and the contrasts of relief reduced, little information has been heretofore obtained regarding these shales. They have been scarcely noted, though they are two and one-half times as thick as the whole upper coal measures were once thought to be. Since their extent has been recognized the Atchison shales have come to assume more and more importance until it has come to be suspected that eventually they may possibly have equal rank with the Des Moines series.

Cottonwood Limestone. The Cottonwood limestone has been adopted as the uppermost member of the Missourian series. The rock was widely known as a quarry stone, long before its importance as a geological formation was recognized, it being called the "Cotton-rock," or "Cottonwood Falls rock" or "Cottonwood stone." Thus, the last two names have crept into geological literature and it seems advisable to adopt the name, especially since other geographic names that have been

applied to it have been found to be preoccupied. Cottonwood Falls and Manhattan, Kansas, may therefore be considered as typical localities. The formation was called many years ago by Swallow the "Fusulina limestone," from its most characteristic lithologic feature, it being composed in certain layers almost entirely of rhizopodous shells, resembling grains of wheat. The stone is widely used for constructional purposes, and is shipped into many states. The stratum has been traced from southeastern Nebraska where it passes beneath the Cretaceous, entirely across Kansas into Oklahoma. It often forms a noticeable topographic feature.

Geological Structure.

Main Features of the Region. So far as the general attitude of the rocks is concerned there is comparative simplicity throughout the whole region that borders the geological section of the Missouri river. There is only a slight tilting of the strata. The greatest inclination is towards the northwest. The initial dip in the district is due to the uprising of the Ozark dome. The rocks herein described are believed to have once extended uninterruptedly over that region, though it is now so much higher, and on it no rocks of Missourian age now rest. While the main dip is northwestward there are minor undulations which modify the mean inclination and in places even reverse the direction of slant. In only a few places is the dip sufficiently great to be perceptible to the eye.

Generalized Geological Cross-section. There are a number of favorable conditions existing along the Missouri river that enable an unusually complete cross-section to be constructed. The stream itself produces numerous good sections when it impinges against its banks. The tributaries entering it flow in deep gorges. Lines of railway on both sides of the river give many fresh fine exposures in their cuttings. A number of deep wells at convenient intervals afford excellent data for checking the underground extension of the strata. The alternation of hard and soft strata enables the different beds to be easily recognized in drill-holes, even when a similar record in another region would prove unsatisfactory or useless.

The most noticeable features in the cross-section is a broad depression—the Brownville syncline, and comparatively sharp

anticline, with Plattsmouth at its crest. The slope from the south end of the section is the general inclination produced by the uprising of the Ozark dome.

The shales appear to become thinner northward; while the limestones seem to vary little in thickness. There is one noteworthy exception in the Iola limestone. This bed which is one of the most important in the series in Kansas rapidly becomes thinner north of Leavenworth. At Atchison and St. Joseph it is not more than a dozen feet in thickness, and disappears entirely before Forest City is reached. The Bethany formation retains its usual thickness so far as the limestones are concerned, but they appear to separate somewhat in the south. With the fading out of the Iola limestone, the Thayer and Parkville shales merge, forming an uninterrupted shale bed 125 feet in thickness. To the northward it becomes reduced to one-third of this measurement. The Plattsburg retains its full development from one end of the section to the other. The Lawrence shales also diminish in thickness towards the north; and the subordinate Iatan limestone appears to merge with the Plattsburg below. The Platsmouth limestone shows no appreciable difference in thickness in the south and north limbs of the syncline. The Platte shales form a lenticular bed, the thickness of which is nearly 200 in the middle of the Brownville syncline, though thinning on each side to 50 feet. The Forbes limestone retains about the same thickness throughout. Only for a short distance in the center of the syncline does this layer disappear below the water-level of the Missouri river. The Atchison shales are about 325 feet thick along the line of the section. This brings the horizon of the Cottonwood limestone, the upper member of the Missourian series, not more than 300 feet above the Missouri river at the lowest point of the syncline.

The Plattsmouth anticline has a gentle slope on the north, but a rather steep slant southward. This fact, which was not recognized until very recently, was no doubt the main cause of much of the confusion that existed regarding the stratigraphy of this part of the section, in the early days of its exploration.

Distribution of Missourian Rocks.

The approximate limits of the Missourian formations are shown on the Missouri and Kansas maps. There are, however, several points in the different districts to which attention should be called.

Nebraska Area. Certain peculiarities in the relations of the geological formations of Nebraska give the Missourian rocks much less areal extent than they ordinarily would be expected to have. The Missourian rocks occupy only the extreme southeastern portion of the state. They extend over all of the county of Richardson, and parts of Pawnee, Nemaha, Otoe, Cass, Sarpy and Douglass counties.

To the northwest the Missourian and the Oklahoman as well, are limited by the overlapping of the Cretaceous. Previous to the deposition of the latter the underlying strata were subjected to profound erosion, and were bevelled off at a considerable angle. In consequence the Cretaceous rocks repose in marked unconformity upon the Carboniferous. The eastern border of the former extends directly southwestward from Omaha.

The formations of the Missourian that are represented in Nebraska are: Cottonwood limestone, Atchison shales, Forbes limestone, Platte shales, Plattsmouth limestone, and a few feet of the Lawrence shales.

Southwestern Iowa District. The relations of the Carboniferous and Cretaceous are essentially the same in Iowa as they are in Nebraska. The younger deposits come in from the northwest and overlap the Missourian, Des Moines and Mississippian series. While normally the Missourian would occupy, as the surface rock, about one-fifth of the total area of the state, it in reality, owing to the Cretaceous covering, forms considerably less than one-half of this extent. The Cretaceous extends southward in a long tongue nearly to the southern boundary of the state. The unconformity of the younger and older rocks is even more marked than in Nebraska.

In Iowa the Missourian formations occupy all of Union, Ringgold, Taylor, Fremont and Mills counties; and parts of Guthrie, Adair, Madison, Clark, Decatur, Adams, Page, Montgomery, Cass, Pottawattamie, Harrison and Monona.

No attempt has ever been made in Iowa to subdivide the rocks forming the Missourian. In fact the published information relating to the formations in this state is of the most meager description. It has always been referred to in the most general way as the Upper Coal Measures. Its unimportance as a formation may be further judged from the fact that it has generally been regarded as being not more than 200 feet thick.

Recent inquiry has indicated beyond all doubt that there are about 1,050 feet of Missourian strata in southwestern Iowa. In the same region there are over 450 feet of Des Moines beds. These figures are derived from various measurements of sections and are corroborated by deep-well records. Although the exact distribution of all the Missourian subdivisons has not yet been accurately traced, it is now known that all eleven of them are present within the limits of the state, except the Iola and Cottonwood limestone. The course of the Bethany in Iowa has been carefully followed by Bain, Leonard and Tilton. Other limestones occur to the west of the Bethany border the position and relations of which long remained unknown. Nor were their distinctions from one another suspected until after the succession had been made out carefully on the Missouri river. In the deep-well sections of this district the formations passed through appear to agree very well with what would naturally be expected to exist. The shales are all very much thinner than they are farther southward. The Nodaway coal bed, the only seam mined in southwestern Iowa, is in the lower part of the Atchison, 75 to 100 feet above the base. The wide extent of this coal bed makes it a distinguishing horizon for a large area.

Northwest Missouri Region. In Missouri, the rocks of the formations under consideration are better known than in any other district. The full thickness of the series is not represented within the limits of the state. As for Iowa, about 1,050 feet may be taken as the actual measurement. The Cretaceous rocks nowhere cover the Carboniferous strata, unless it be in a few small isolated patches in Nodaway county. Of these, however, there is no evidence of existence.

The Missourian series forms the surface rock in all, or nearly all, of sixteen counties. Small areas occur in at least

eight others. The formations represented include all except the Cottonwood limestone. The nearest outcrop of the latter is 15 miles from the state boundary.

Owing to peculiarities in drainage and slight folds, the eastern margin of the series is very sinuous. In the shallow syncline in the northcentral part of the state the limestone extends as outliers as far east as Milan, in Sullivan county. On the other hand, in the deep trough of the Missouri river, the rocks constituting the series are almost completely cut out at Kansas City, leaving two distinct areas in the state.

Some of the formations of the Missouri river region were early distinguished, and in at least three cases special names were given. These titles have been retained in the present connection. Much data has accummulated regarding the rocks of this region and it is now being put in suitable condition for publication.

Kansan Area. The Missourian rocks occupy a belt, in this state, 50 to 90 miles wide. They may be regarded as extending over all of that part of Kansas east of a line drawn through Seneca, Topeka, Emporia and Eureka, except a small portion of the extreme southeastern corner of the state, where the Des Moines series is found. All the formations making up the series are fully represented. The Kansas geologists have made estimates on the thickness of the rocks of the state. They place the combined Des Moines and Missourian at about 2,400 feet. This is evidently excessive, even according to the same data they have used. Some minor subdivisions of several of the formations are also recognized in the state, but they are only of local importance. The large streams cross the Missourian belt nearly at right angles to the strike. This gives some unusually good sections, and tends to accentuate the characteristic topography of the belt.

Southern Extension. South, beyond the limits of Kansas, little is known of the details concerning the Missourian rocks. The part of the Verdigris valley, in Indian territory, and that part of the Arkansas valley north of the river appear to be occupied by the rocks of this age. The Pawhaska limestone, in the Osage nation, is probably the Iola. The series probably extends into the Creek country, and the Choctaw nation, but is

found not to enter Arkansas at any point. A narrow belt in eastern Oklahoma is also made up largely of these same strata.

RECAPITULATION.

From the consideration of the foregoing description of the section displayed by the gorge of the Missouri river several conclusions of interest may be deduced:

1. The title of Upper Coal Measures is inappropriate for the series of rocks, commonly called by that name, though several thin seams of coal are known to occur in the formation. Had the series been even partially understood early in the period when it was first investigated geologically the name of Coal Measures would probably never have been suggested.

2. In their most characteristic facies the Missourian rocks are essentially marine beds.

3. The Missouri River section may be taken as the typical one of the Missourian series. The stream cuts through the entire formation exposing in its full development every subdivision.

4. The Missourian is a well defined series. It contrasts strongly with the other series of the Carboniferous of the region in all its topographical, lithological, stratigraphical, and biological characters.

5. The subdivisions here recognized have a wide geographic extent.

6. The Missouri River section provides a standard for comparison of the formations for the whole Western Interior region. Uniformity in description may now be considered as prevailing in five states and two territories and a comparison of results may be readily made.

[Contributions to the Mineralogy of Minnesota. VII.]

ADULARIA AND OTHER SECONDARY MINERALS OF THE COPPER-BEARING ROCKS.

By N. H. WINCHELL, Minneapolis, Minn.

Adularia. Prof. J. D. Whitney gave an analysis of a mineral found* by him at Copper Falls and at Douglass Houghton mine, Keweenaw point, where it occurs implanted on quartz and copper, and which gave the following analysis:

Silica	65.88
Alumina	17.35
Oxide of Iron	.57
Potash and soda (by loss)	16.20
	100.00

He made no direct determination of the alkalies, not having been able to obtain enough of the substance for such analysis.

A similar mineral was found by the writer at the Minong mine on Isle Royale, where it forms a thick coating on metallic copper, and is associated with calcite. It also forms geodic coatings and in these cavities (though small and irregular) can be seen and studied the crystalline form and faces. The mineral is insoluble and infusible, or difficultly fusible. In a tube it gives no water. By the Boricky and the Behrens tests for potash, many characteristic crystals were obtained. By the former method some lime and some soda were also indicated, but plainly in subordinate amounts. The crystals are small (from 1. to 1.5 mm in transverse diameter) and have a glassy transparency between crossed nicols. The fracture is irregularly conchoidal, but governed partially by the cleavage. Broken at random the fragments give more numerous cleavages in which the axis n_m is vertical than those having n_g vertical. The crystals are confusedly mingled and apparently compounded by parallel but slightly irregular growths, which cause an extinction which is not simultaneous, but takes place on one side sooner than on another. The acute optic angle is small and contains n_p the appearance being almost that of a uniaxial mineral unless the image be well centred.

The crystals are mono-clinic and the prismatic faces are the only faces of the perpendicular zone, the optic plane being parallel to the diagonal of a cross-section. Refraction and double

*Report on the Lake Superior land district. Part II, p. 102, 1851.

refraction are low, the specific gravity is 2.544. The angle included by the prisms is 61° 30′. Extinction angle on cleavage (001) is not always parallel, but sometimes departs 9° from parallel. The undulatory extinction resembles that of sections of the adularia, from the dome de Gouter, of the Alps, which are in the laboratory of Mineralogy of the Museum d'Histoire Naturelle, Paris.

Locality— Monong Mine, Isle Royale.

Wollastonite. Prof. J. D. Whitney also gives two analyses of wollastonite, from Scoville point, Isle Royale, viz.:

Silica	49.09	49.09
Lime	46.38	44.87
Protoxide manganese	.48	.93
Alumina	.23	1.29
Magnesia	.14	....
Water	2.96	2.96
Carb. Acid and loss	.72	.90
	100.000	100.00

He remarks that this mineral is "remarkable for its toughness, which quality it seems to possess in a higher degree than any known mineral." He describes this mineral as "compact, with uneven fracture, color light flesh red, hardness 6, lustre resinous to pearly, readily decomposed by acids, the silica separating in the form of a flocky precipitate". The water, dried at 100° C. was found by two determinations 2.96 and 2.96. "Still the quantity seems too small to allow it to be considered as forming an essential part of the mineral, as it retains all its properties unchanged after ignition. It receives a beautiful polish." This mineral has not since been reported from Isle Royale.

Prehnite. This is not very common, but occurs at French river, a few miles east of Duluth. It fills and lines numerous cavities, and embraces metallic copper. At Knife river it occurs in a scoria. It is more common on Isle Royale where it is associated with thomsonite and other zeolites and also embraces metallic copper in isolated nuggets.

Delessite forms small spherulites in numerous places in the diabasic rocks. It is sometimes wholly within some of the zeolites, as thomsonite, and chlorastrolite.

MODIFIED DRIFT AND THE CHAMPLAIN EPOCH.

BY WARREN UPHAM, St. Paul, Minn.

Some American glacialists prefer other terms instead of these presented in the foregoing title; and one of the latest expressions of such preference is by my friend, Mr. J. B. Woodworth, in his paper, "The Ice-contact in the Classification of Glacial Deposits" (Am. Geologist, xxiii, 80-86, Feb., 1899). That paper, in accordance with general usage, includes all the products of glaciation under one comprehensive name, drift, whether directly laid down by an ice-sheet or removed from the ice and deposited, after being more or less worn and assorted, by the running water of the glacial melting and of rains or by the laving action of adjoining lakes or the sea.

For the two primary classes of the drift, distinguished thus genetically in the conditions of their deposition, I believe that the contrasted terms, glacial drift and modified drift, which have been long in use, are the most expressive, euphonious, and serviceable. To show reasons for the retention and general acceptance of these terms is the purpose of the earlier and principal part of the present paper. In its later part, attention is directed to the value in chronologic classification, and to the large significance, of the Champlain epoch, during which (as the term has been used by Dana, C. H. Hitchcock, Le Conte, and others, including the present writer) the modified drift, marginal moraines, and apparently the greater part of the till, were deposited upon the glaciated regions of North America and Europe, excepting only comparatively small outer areas, which were ice-enveloped in the early or middle parts of the Glacial period, but not in its closing stages constituting the Champlain epoch.

GLACIAL DRIFT.

The first great class of drift deposits, formed by the ice alone, which Woodworth calls the "till group," includes some varieties which cannot be regarded as till, the most noteworthy, perhaps, being belts and shorter tracts of very abundant boulders forming parts of moraines or closely associated with moraines of ordinary till and kames. Hence it seems to me preferable that this class or group be called glacial drift, noting the method of origin and deposition of its several formations, as (1) subglacial till, including usually the chief mass of the drift

sheet and of drumlins; (2) englacial or intraglacial drift, which became superglacial by ablation of the ice-sheet, thence being deposited as an upper till; and (3) marginal moraines, in their diverse phases of development, so far as they consist of till or boulders and other drift not due to stream deposition.

Because of changes in the course and relative strength of glacial currents, deposits of till of different origin and therefore unlike in their rock materials and color, in the derivation and proportions of their boulders, etc., form in some districts, as on the Duluth & Iron Range railroad in northeastern Minnesota, several beds in a single drift sheet, even where all are probably referable to one uninterrupted general stage of glaciation.* It is quite in accordance with prevailing geologic usage to speak of these diverse deposits of till, overlying one another in a single sheet, as beds or strata. Furthermore, layers of modified drift occasionally intercalated in till may give it a stratified appearance, although all the till should have the same origin and character. On the other hand, some portions of our coarsest deposits of modified drift gravel and sand, with waterworn and rounded cobbles and boulders, sometimes up to two or even three feet in diameter, as in many eskers and kames in the hilly and mountainous region of New England, present sections having no evident stratification or assorted condition through thicknesses of 5, 10, or 20 feet. It is thus seen that the other terms based on evidence of stratification, which have been proposed for these great classes, as unstratified drift and stratified drift, are not fully satisfactory.

Modified Drift.

The grand two-fold classification of the drift was very clearly recognized by Dr. Edward Hitchcock in 1857, its water-laid formations being collectively described and named as follows:

> When drift has been acted upon by waves, or currents of water, the boulders are reduced in size, they are smoothed and rounded, their striæ are generally obliterated, and all the materials are redeposited in regular layers, being sorted into finer and coarser deposits, according to the velocity of the currents. These I call modified drift.†

*Geol. and Nat. Hist. Survey of Minnesota, 22d Annual Report, for 1893, pp. 41-45, with four sections.

†Illustrations of Surface Geology, p. 4. This paper, accepted for publication, January, 1856, forms pages viii, 155, with 12 plates, in Smithsonian Contributions to Knowledge, vol. ix, 1857.

This term was used by the same author four years later, in the report on the Geology of Vermont (vol. i., p. 56). The definitions in each of these works imply that the deposition of the glacial drift antedated that of the modified drift. The origin of both through glacial action, the former directly, the latter indirectly, and their essentially contemporaneous deposition, were not yet well understood; but the imperfection of knowledge, at that time, concerning the processes by which the drift was produced, should not invalidate the judicious and well defined classification and terminology. To me it seems just as suitable to preserve this name, modified drift, as if the origin of the drift through the agency of land ice, and the conditions of aqueous modification of large parts of it, had been completely ascertained when the name was first proposed. It has a priority of forty-two years, in comparison with the term, "wash group," which is proposed by Woodworth for the same grand class of drift formations.

In my report on the "Modified Drift in New Hampshire," the derivation of this water-laid drift is attributed to the ice-sheet; and its subsequent sculpturing from broad and thick flood-plains into terraces in the large river valleys is shown to have been in progress from the closing part of the Ice age to the present time, although it was doubtless mostly done soon after the ice retreated. The characteristic development of the modified drift, as seen in the Connecticut, Merrimack, Androscogin, Saco, and other valleys is described as follows, with reference to the change of interpretation of the conditions of its origin:

> The deposits included under this title are the waterworn and stratified gravel, sand, and clay or silt, which occur abundantly in almost every valley in the state. These river-lands comprise the intervals, which are annually overflowed at the high water of spring, and successive terraces which rise in steps upon the side of the valley, the highest often forming extensive plains.
>
> The origin and distribution of these materials present many interesting questions. When the term was first employed, it was the prevailing opinion that modified drift was gradually formed from the unmodified glacial drift by the ordinary action of rain and streams..... It it evident, however, that the high terraces and wide plains bordering our rivers were formed by much greater floods than those of the present time laden with vast quantities of alluvium. Both the materials and the water for sweeping them into the valleys appear to have been supplied

the melting of an immense sheet of ice. The deposits thus had the same origin with the glacial *drift;* but they have been ***modified***, being separated from the coarser portions, and further pulverized or rounded, and assorted in layers, by water.*

According to such definition, and constantly recognizing the progressive deposition of both glacial and modified drift, with extension of their areas, as fast as the ice boundary retreated, these terms are employed throughout my reports for the Geological Survey of Minnesota (1879 to 1888, and again in 1893 and 1894), on the glacial lake Agassiz for the Geological Survey of Canada (1890) and for the United States Geological Survey (Monograph XXV, 1895), and in numerous papers published by the Geological Society of America.

Without attempting here a detailed description of the various deposits or types of modified drift, dependent on diverse conditions of deposition, we may briefly characterize them as including (1) valley drift, related to present courses of drainage, with which I class the chief development of the loess in the Missouri and Mississippi basins; (2) gravel, sand, and finer silt plains, not related to present streams, but representing areas of fluvial and lacustrine deposition when the part of the ice-sheet adjoining them was being melted away; (3) sand and gravel plateaus, and the loess paha of Iowa, more distinctly recording the ice borders against which they were amassed; (4) eskers, growing in length as the ice receded, being deposited in channels of ice-walled streams at and near their mouths; (5) kames, differing from eskers in the short duration of their parent glacial streams, best developed in marginal moraine belts; and (6) water-laid beds intercalated with till in drift sheets, drumlins, and marginal moraines.

The volume of the modified drift in the New England states and westward to Minnesota, the Dakotas, and Manitoba, according to my observations and estimates, may average varyingly a quarter to a half as much as the volume of the till. It was almost wholly supplied, with a considerable part of the till, as I believe, from drift that continued to be englacial or intraglacial until ablation of the ice gave it over to rain and stream erosion, transportation, and deposition.

*Geology of New Hampshire, vol. iii, 1878, pp. 3, 4.

THE GLACIAL AND CHAMPLAIN EPOCHS.

Dana, in his presidential address before the American Association in 1855, announced the three epeirogenic movements, as they are now termed, which characterized the Glacial period, namely, (1) high uplifts of the countries that became enveloped with snow and ice; (2) depression of these countries until mainly they were lower than now by vertical amounts ranging, in North America, to about 500 feet; and (3) a moderate reëlevation to the present hight. The fossiliferous beds of marine modified drift in the St. Lawrence and lake Champlain valleys, at first named Lawrentian deposits by Desor, were described by C. H. Hitchcock, in 1861, under the name Champlain clays in the Geology of Vermont (vol. i., pp. 156-167), whence the name Champlain epoch was soon applied by Hitchcock and Dana to the time of depression and coastal submergence of the drift-bearing northern part of our continent terminating its glaciation.

With the progress of observation and study of the drift formations by Dana, N. H. Winchell, the present writer, and others, it was learned more than twenty years ago that the ice-sheet inclosed much drift in its lower part, which during its final melting became exposed on the ice surface, thence to be partly washed away and laid down as modified drift, while the remaining part fell loosely to the ground as an upper till. The recession and disappearance of the ice-sheet, brought about by the Champlain subsidence and consequent restoration of a temperate climate on the ice border, were attended with deposition of the previously intraglacial drift, marking the Champlain epoch as the especial time of abundant and rapid accumulation of drift, made possible by the much longer time of its erosion and transportation during the oncoming and culmination of the Ice age.

Epeirogenic movements, first of great uplift and later of depression, are thus regarded as the basis of the two chief time divisions of this period. Each of these epochs is further divided in stages, marked in the Glacial epoch by fluctuations of the predominant ice accumulation, and in the Champlain epoch by successively diminishing limits of the waning ice-sheet, which, however, even then sometimes temporarily reädvanced.

The abundant intraglacial drift that was being transported very slowly at hights not far above the ground appears, during the glacial recession, to have been at last carried downward beneath the outer part of the ice-sheet, probably in some degree on account of basal melting of the ice, being then amassed in the usually flat or moderately undulating ground moraine. Under certain peculiar conditions, due to climatic influences, I suppose that great quantities of the ice-held drift, having once become superglacial, were again covered by onflowing ice and heaped by its convergent descending currents in the high oval hills of till called drumlins. When the North American ice-sheet attained its greatest extent, erosion probably was in progress on all the ice-covered country, excepting near its limits, being most rapid within some such distances as from 100 miles to 200 or 300 miles back from the boundary. Deposition prevailed, we may infer, on a submarginal belt, and the disappearance of the ice-sheet, during the Champlain epoch, was attended by the recession of this belt, estimated to have been 20 to 50 miles wide, across all the previously eroded country. The intraglacial drift suplied by the wide and long continued erosion was then laid down, according to the view here presented, in great part and apparently more than half of it all, as the ground moraine of subglacial till; and the remainder formed the upper till, retreatal moraines, and all the superficial modified drift, including kames, eskers, paha, and plateau, plain, and valley drift in their varieties of gravel, sand, clay, and loess.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Mineralogical Notes: Analyses of Tysonite, Bastnasite, Prosopite, Jeffersonite, Covellite, etc. By W. F. HILLEBRAND. Am. J. Sci., 157, 51-57.

The analyses of the following minerals were made in the laboratory of the U. S. Geological Survey. 1. Tysonite and bastnäsite. Analyses of fine specimens from Cheyenne Mt., near Pikes Peak, Col., agreed essentially with those of Allen and Comstock. The formulas $R'''F'_3$ for tysonite and $R'''(F', CO_3'')$ for bastnäsite, which in the absence of

fluorine determinations have not hitherto been confirmed, are shown to be correct. The analyses show some 40 per cent of Ce_2O_3 (including ThO_2), with a little less of the La group. 2. Prosopite. A beautiful pale green mineral from Utah, supposed by Kunz to be utahlite, proved on analysis to be prosopite, mixed with quartz and flourite (?), and colored by some copper salt. Comparison with Altenberg and Pikes Peak prosopites shows a close agreement except in amounts of F and H_2O, the variation of these two affording further evidence as to their mutual replacement by one another. 3. Jeffersonite. An analysis of a brown mineral from Franklin Furnace, N. J., agrees closely with that of jeffersonite but its physical properties differ from hitherto published data of that mineral. The author considers the analysis chiefly valuable as showing a wide range of composition for the mineral. 4. Analyses are also given for covellite, enargite, and a blue stalactite from Butte, Montana, and a fibrous sulphate corresponding to the empirical formula $(FeMn)_4(ZnMg)_8Al_2(SO_4)_9\,65H_2O$ from near Whitehall, Montana. M. L. F.

On the Chemical Composition of Tourmaline. By S. L. PENFIELD AND H. W. FOOTE. Am. J. Sci., 157, 97-125.

This important mineralogical contribution consists essentially of an elaborate review and critical discussion of the investigations of Rammelsberg, Riggs, Jannasch and Kalb, and others upon the constitution of tourmaline. Two new and carefully executed analyses are given which agree closely with those of previous investigators. Rammelsberg's conclusion that all tourmalines are derived from the acid H_4SiO_5 was based on analyses which the authors have shown to be defective. On applying the necessary corrections, however, the general formula $H_{20}B_2Si_4O_{21}$ may be derived, which agrees with that obtained by Riggs, Jannasch and Kalb, and the authors. A critical examination of the many published analyses, taken in connection with their own analyses of exceptionally pure specimens, leads the authors to the conclusion that all varieties of tourmaline are to be considered as salts of the acid $H_9Al_3(B.OH)_2Si_4O_{21}$, in which the complex aluminium-borosilicic acid radical exerts a mass effect by virtue of which the remaining hydrogens may be replaced by numerous metals of essentially different characters without any pronounced effect on crystalline form. The table of the ratios R′ : R″ : R‴ : H, derived from some 35 analyses, including practically all varieties thus far investigated, shows that although certain prominent types undoubtedly exist, the ratios do not approach closely enough to rational members to give definite formulas.

M. L. F.

Notes on North Carolina Minerals. By J. H. PRATT. J. Elisha Mitchell Sci. Soc., 14, pt. 2, 61-83.

The notes on four of the nine minerals considered in this article, wellsite, anorthite, cyanite and zircon, have been published elsewhere and noticed in this review. The remaining species are chabazite, anthopyllite, enstatite, enstatite (bronzite), and emerald beryl. The chab-

azite occurs as minute crystals coating feldspar,hornblende and corundum and intimately associated with the wellsite, in a corundum mine in Clay county. Two analyses are given; and the ratio of Al_2O_3 to the protoxide bases is found to be somewhat below the normal. The anthophyllite, which occurs in dunite rock near Bakersville, was originally described by Penfield in 1890, before the locality was known. A new analysis is given, and Penfield's analysis is quoted for comparison, the two agreeing very closely, and closely approximating the normal composition. The enstitite forms rock masses bordering the dunite of Corundum hill. The analysis indicates the admixture of 35 per cent of serpentine and 20.5 per cent of talc, the pure enstatite forming but 44.5 per cent of the whole. The bronzite forms with an emerald-green diopside a tough rock (websteryte) in the dunite of the Tuckaseegee valley; and the websteryte also varies to a nearly pure bronzite rock. The analysis and physical characters show this to be a very typical bronzite. The emerald beryl occurs in a vein of pegmatyte, and is in part of gem quality; but it has not been analyzed. All of the new analyses of the foregoing minerals were made by Chas. Baskerville of the N. C. Geological Survey. W. O. C.

The Origin and Chemical Composition of Petroleum. A Symposium. By S. P. SADTLER, S. F. PECKHAM, DAVID T. DAY, FRANCES C. PHILLIPS AND CHARLES F. MABERY. Proc. Am. Phil. Soc., 36, 93-140.

This paper is a valuable summary of our knowledge of petroleum and natural gas, and in a measure of all of the native bitumens. Prof. Sadtler discusses the genesis and chemical relations of petroleum and natural gas; and rejecting all the theories of the inorganic origin of these bodies, and weighing carefully the rival theories of their derivation from animal tissues and from plants, concludes, partly from original experiments with linseed oil, that both the theories of their organic origin are required to explain all the facts. Prof. Peckham's contribution is on the nature and origin of petroleum, setting forth at some length the facts which appear to sustain the distillation theory, which is made to cover all the native bitumens from natural gas to asphaltum. Dr. Day develops a suggestion as to the origin of Pennsylvania petroleum which is a modification of Mac Gonigle's theory that the Pennsylvania oils have been derived by distillation from the underlying Silurian strata, the transfer from the lower to the higher formations,, with a notable increase in density and loss of sulphur, having, according to Day, been accomplished, not by distillation but by an upward filtration through beds of shale. Prof. Phillips discusses and accepts provisionally Mendeléeff's theory that metallic carbides have been produced deep in or below the earth's crust, and that these carbides have been decomposed by steam, giving rise to the various hydrocarbons of oil and gas; and in accordance with this view the author argues strongly against the view that petroleum occurring in the cavities of fossils is indigenous in them. Prof. Mabery, in considering the composition of American petroleum, notes the progress of our knowledge, the difficulty of correlating the composition or specific gravity with the dis-

tribution or geological occurrence. Even the high sulphur oils, which some have regarded as peculiar to limestones, are shown to be also very typically developed in sandstones and shales. The importance and feasibility of a general system of classification on the basis of the series of hydrocarbons which constitutes the main body of the crude oils are discussed at some length. W. O. C.

The Genesis of Bitumens, as Related to Chemical Geology. By S. F. PECKHAM. Proc. Am. Phil. Soc., 37, 108-139.

This paper is a sequel to the preceding symposium; but the author contents himself with a very general discussion of the geology of the bitumens and especially of petroleum, and a restatement of the facts supporting the distillation theory of petroleum and natural gas.

W. O. C.

On Dikes of Felsophyre and Basalt in Paleozoic Rocks in Central Appalachian Virginia. By N. H. DARTON. *Notes on the Petrography* By ARTHUR KEITH. Am. J. Sci., 156, 305-315.

A third locality of igneous rocks in the Central Appalachian region has recently been discovered by Mr. Darton. Both basic and acidic dikes are represented, the latter belonging to the granite family and most nearly resembling felsophyre. Petrographic descriptions of both types are given by Mr. Keith, supplemented by an analysis of the felsophyre by W. F. Hillebrand. M. L. F.

Platinum and Iridium in Meteoric Iron. By JOHN M. DAVISON, Am. J. Sci. 157, 4.

After treating the Coahuila and Toluca meteoric irons with hydrochloric acid, there remained in each case a fine black residue consisting of irregular or tetragonal crystals of rhabdite, carbon, and some stony matter. Analyses of these sediments showed the presence of both platinum and iridium. From 608.6 grams of Coahuila iron there were obtained 0.014 gram of platinum, and 0.0015 gram of black powder, probably iridium. The amounts obtained from the Toluca iron were considerably less. Unsuccessful search was made for microscopic diamonds. M. L. F.

Causes of Variation in the Composition of Igneous Rocks. By T. L. WALKER. Am. J. Sci., 156, 410-415.

A brief review is given of the usual theories of magmatic differentiation. The author considers that none give satisfactory explanations of all the phenomena observed, especially of the excessively basic centers of certain eruptive masses. Attention is called to the fact that certain homogeneous solutions remaining for a long time at constant temperatures become gradually more concentrated in the lower portion, and it is urged by the author that a similar concentration probably occurs in complex silicate magmas, especially when near the temperature of consolidation. The material along the borders solidifies before the differentiation is far advanced, representing the original composition. Differentiation and solidification progress simultaneously, and hence the central portions will have suffered the greatest changes. In the

upper horizons of the eruptive there would be an increase in acidity towards the center; the middle horizons would show little differentiation, while the lower horizons would show an increase in basicity towards the center. These relations are illustrated graphically by a diagram. It is not considered that this is ever a sole cause of differentiation. The ability of gravitation to produce concentration in solutions is denied by some physicists, but is upheld by those who have investigated it most carefully. M. L. F.

On the Associated Minerals of Rhodolite. By W. E. HIDDEN AND J. H. PRATT. Am. J. Sci., 156, 463-468.

The more common associated minerals of this new variety of garnet are quartz, corundum, pleonaste, gahnite, chromite, iolite, staurolite, monazite, zircon, gold and sperrylite. The occurence of each is described and analyses by Chas. Baskerville are given for gahnite and iolite. M. L. F.

The Alkaline Reaction of Some Natural Silicates. By F. W. CLARKE. J. Am. Chem. Soc., 20, 739-742.

On adding distilled water containing a very little alcoholic phenolphthalein to samples of certain finely pulverized silicates, including micas, feldspars, zeolites, etc., alkaline reactions were immediately obtained. As would be expected, the colors were most intense in the case of those minerals which in nature are most subject to alteration. Similar results were also obtained from tests upon the common igneous rocks. The rapidity of the action is a striking feature. M. L. F.

Petroleum Inclusions in Quartz Crystals. By CHAS. L. REESE. J. Am. Chem. Soc., 20, 795-797.

Crystals of quartz with petroleum inclusions from Marshall Co., Ala., are described and illustrated. The petroleum was recognized by its fluorescence, odor and combustibility. M. L. F.

Mineral Resources of Cuba. By RAIMUNDO CABRERA, translated by L. E. LEVY. J. Franklin Inst., 146, 26-41.

Descriptions and analyses are given of the more important ores and economic deposits including asphaltum, phosphate rock, and the ores of gold, silver, lead, copper, iron and manganese. M. L. F.

The Slate Regions of Pennsylvania. By MANSFIELD MERRIMAN. Stone, 17, 77-90.

A description is given of each of the principal slate-producing regions, accompanied by tables of statistics relating to the output and properties of the slates. The probable resistance to corosion by smoke, sulphurous vapors, etc., was tested by treatment for 63 hours in a 2 per cent. solution of $HCl + H_2SO_4$. The results are given in a tabulated form.

M. L. F.

Iron Making in Alabama. By WILLIAM BATTLE PHILLIPS. Second Edition. Alabama Geological Survey, Eugene Allen Smith, Director; Montgomery, Ala., 1898. Pages viii, 380.

The first edition of this report, issued in 1896, is now succeeded by an

enlarged edition, adding chapters on pig iron, steel making, coal washing, etc. In production of iron ores Alabama ranks third among the states of the Union, being surpassed only by Michigan and Minnesota; while in the home manufacture of iron from her own ore Alabama ranks first. Her product of pig iron in 1897 was 947,831 long tons (of 2,240 pounds), at an average cost of about $6 per ton. For the same year her iron ore product was 2,098,621 tons, valued at $0.74 per ton, being in quantity about an eighth, and in value about a twelfth, of the whole product of the United States. Phosphorous is present in the Alabama ores to such amount that they yield no iron of Bessemer grade; but their iron is successfully used for the manufacture of steel by the basic open hearth process. W. U.

A Guide to the Study of the Geological Collections of the New York State Museum. By FREDERICK J. H. MERRILL, Director. Bulletin of the N. Y. State Museum, Albany, Vol. 4, No. 19, November, 1898. Pages 105-262, with 118 plates and a folded geologic Relief Map of the State. Price 40 cents.

In this comprehensive summary of the stratigraphic and economic geology of New York, with it concise introduction to the science of geology, the people of that state, including its teachers and pupils, are supplied a most admirable manual for use in visiting the State Museum and in field observations of the rock formations. Among the many plate illustrations, all made from photographs, are numerous quarries, and the natural geologic sections of the Ausable chasm, the Niagara gorge, the Genesee gorge at Rochester, and many other localities of grand and beautiful scenery. By these examples the learner is led to examine the rocks of his own neighborhood as exposed by stream or lake erosion or by quarrying.

The paleontology of the state is not here considered, excepting in the briefest way requisite for the description of the stratigraphy and areal geology; but it is hoped that another handbook, treating of the fossils will be prepared by Prof. John M. Clarke, the state paleontologist. W. U.

On hardystonite, a new calcium-zinc silicate from Franklin Furnace, New Jersey. By JOHN E. WOLFF. (Proc. Am. Acad. Arts and Sci., vol. 34, no. 18, pp. 477-481, Apr. 1899.)

This mineral, which occurs in small white grains, was found in the new workings at North Mine hill, Franklin Furnace, associated with willemite, rhodonite and franklinite. Analyses, omitting impurities and calculated to a basis of 100, show the composition to be: SiO_2, 38.34; ZnO, 25.88; CaO, 35.78. This does not include small amounts of MnO (1.43) and MgO (1.61). The formula is ZnO, 2CaO, $2SiO_2$. The grains of this mineral exhibit no distinct crystal boundaries, but cleavages and optical properties show it to be tetragonal. There is a good basal cleavage and also secondary cleavages parallel to the prisms of the first and second orders. The optical sign is negative and the birefringence is strong. The name hardystonite is taken from Hardyston township in which the Franklin mines are situated. U. S. G.

Report on the Boundary between the Potsdam and Pre-Cambrian Rocks, north of the Adirondacks. H. P. CUSHING. (Geol. Survey of New York, Annual Report for 1896, published in separata, 1898.)

This is essentilly a report of field observations, accompanied by a map showing the approximate boundary of the southern limit of the Potsdam sandstone through Franklin county and to and beyond Potsdam in St. Lawrence county. Under the term Potsdam are included all the strata of sandstone below the Calciferous, which is in accord with the usual practice in New York. It is probable however that two non-conformable (or slightly discordant) sandstones are here included, and that these represent the two sandstones which in the lake Superior region are separated by an important igneous disturbance, and sometimes by non-conformity, viz: the upper portion of the Keweenawan eruptives.

The author improved his oppportunities to gather important data concerning the pre-Cambrian rocks, and his occasional comments on their nature and structures are very suggestive. For instance, in his account of the "sequence of geologic events in the Adirondacks" (p. 9) he states that, though there are three series of gneisses, normally, yet the first two so completely grade into each other that it is questionable whether there should be any attempt to separate them; while the third grades into augite-syenytes and gabbroitic rocks, passing into them either by insensible gradations or becoming finely interbanded with them. "They also seem to grade into the basic gabbros of the region; at least these present phases practically not to be distinguished from them." The gneisses of this series, which appear to be younger than the others, and perhaps the equivalent of the Grenville of Logan, differ widely from the others, and appear in large part to be "unquestionably of sedimentary origin," with complete loss of clastic structure. These statements, when coupled, point to the possible or the probable sedimentary origin of some phases of the basic gabbros into which the sedimentary gneisses seem to grade. This is an important result of field studies, and is entirely in keeping with observations made by the writer on the relations of certain schists and basic gneisses to the muscovadyte rock which is one of the phases of the great gabbro mass of Minnesota. N. H. W.

Augite-syenite gneiss near Loon lake, New York. H. P. CUSHING. (Bull. Geol. Soc. Am., Vol. X, pp. 177-192, Apr. 1899.)

In this more detailed study the author gives further important data concerning the petrographical and chemical as well as the structural relations of some syenytes to certain quartzose sedimentary gneisses which lie alongside, having the same direction of foliation, dip and strike. The general impression is that the two constitute a regularly bedded series, but from general considerations based on preconceived ideas and on the chemical composition he concludes that the augite syenyte is an igneous rock.

The microscopical description recalls the augite-syenytes of the Keweenawan rocks of the Lake Superior region, which in a

similar way are intimately associated with the gabbro and which are also, in a measure, allied petrographically and perhaps structurally, with the muscovadyte. This whole series, as stated by Cushing, is an exceedingly varied one, whether in the Adirondacks or in the Lake Superior region. As igneous rocks they shade off toward the gabbro and also become very granitic and acid. In their bedded or leaved conditions they seem to grade into the Grenville series in the Adirondacks, and into the muscovadyte series in the region of lake Superior. As distinctly igneous rocks they are younger than the associated fragmental (gneisses), and as metamorphosed clastic rocks they are of the same age as the Grenville in one place, and as the muscovadyte in the other.

Owing to this great variation in composition and in structure it may be doubted whether any chemical composition can be considered typical and characteristic. It is evident that field studies are mainly to be depended on to furnish the key to the relations and origin of this series of rocks. It is also pleasant to know that Prof. Cushing has entered, apparently, upon this branch of inquiry into the geology of the Adirondacks with thoroughness and with a just appreciation of the value of field study. N. H. W.

MONTHLY AUTHORS' CATALOGUE OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

Calvin, Samuel.

Iowan drift. (Bull. Geol. Soc. Am., vol. 10, pp. 107-120, Mch. 7, 1899.)

Case, E. C.

The development and geological relations of the vertebrates. V. Mammalia, continued. (Jour. Geol., vol. 7, pp. 163-187, Feb.-Mch. 1899.)

Crosby, W. O.

Geology: south shore [near Boston, Mass.]. (Guide to localities illustrating the geology, etc., of the vicinity of Boston, pp. 21-31. A. A. A. S., 50th anniversary meeting, Boston, August, 1898.)

Cushing, H. P.

Augite-syenite gneiss near Loon lake, New York. (Bull. Geol. Soc. Am., vol. 10, pp. 177-192, pls. 19-20, Apr. 1, 1899.)

Daly, R. A.

A comparative study of etch-figures. The amphiboles and pyroxenes. (Proc. Am. Acad. Arts and Sci., vol. 34, no. 15, pp. 371-429, pls. 1-4, Mch. 1899.)

*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Daly, R. A.

On a new variety of hornblende. (Proc. Am. Acad. Arts and Sci., vol. 34, no. 16, pp. 431-437, Mch. 1899.)

Davis, W. M.

Physiography [of the region about Boston, Mass.] (Guide to localities illustrating the geology, etc., of the vicinity of Boston, pp. 1-7. A. A. A. S., 50th anniversary meeting, Boston, August, 1898.)

Davis, W. M.

The peneplain. (Am. Geol., vol. 23, pp. 207-239, pl. 7, Apr. 1899.)

Ells, R. W.

The mineral resources of the Ottawa district. (Ottawa Naturalist. vol. 13, pp. 14-21, Apr. 1899.)

Emerson, B. K.

Geology: Turner's Falls region. (Guide to localities illustrating the geology, etc., of the vicinity of Boston, pp. 33-35. A. A. A. S., 50th anniversary meeting, Boston, August, 1898.)

Fairchild, H. L.

Glacial lakes Newberry, Warren and Dana, in central New York. (Am. Jour. Sci., ser. 4, vol. 7, pp. 249-263, pl. 6, Apr. 1899.)

Forsyth, A. (O'Harra, C. C., and)

Notes on the geology and mineral deposits of a portion of the southern Black hills. (Bull. South Dakota School of Mines, 41 pp., Jan. 1899.)

Grabau, A. W.

Palæontology; eastern Massachusetts [with bibliography]. Guide to localities illustrating the geology, etc., of the vicinity of Boston, pp. 37-62. A. A. A. S., 50th anniversary meeting, Boston, August, 1898.)

Gulliver, F. P.

Planation and dissection of the Ural mountains. (Bull. Geol. Soc. Am., vol. 10, pp. 69-82, pl. 10, Feb. 25, 1899.)

Hague, Arnold.

Early Tertiary volcanoes of the Absaroka range. (Geological Society of Washington, pp. 3-25, pls. 1-3, Apr. 1899. Science, new ser., vol. 9, pp. 425-442, Mch. 24, 1899.)

Hay, O. P.

On one little known and one hitherto unknown species of Saurocephalus. (Am. Jour. Sci., ser. 4, vol. 7, pp. 299-304, Apr. 1899.)

Hill, R. T.

The mineral resources of Porto Rico. (20th Ann. Rept. U. S. Geol. Survey, pt. 6, pp. 1-10, 1899.)

Hitchcock, C. H.

Ancient glacial action in Australasia. (Am. Geol., vol. 23, pp. 252-257, Apr. 1899.)

Hollick, Arthur.

Additions to the palæobontany of the Cretaceous formation on Staten island. No. II. (Ann. N. Y. Acad. Sci., vol. 11, no. 20, pp. 415-430, pls. 36-38, Oct. 13, 1898.)

Hovey, E. O.

Dr. Hovey's report of the late meeting of the Geological Society. (Am. Geol., vol. 23, p. 266, Apr. 1899.)

Kain, S. W. (Matthew, G. F., and)

On artesian and fissure wells in New Brunswick. (Bull. Nat. Hist. Soc. of New Brunswick, vol. 17, pp. 143-152, 1899.)

Kirchner, W. C. G.

Contributions to the fossil flora of Florissant, Colorado. (Trans. Acad. Sci. of St. Louis. vol 8, no. 9, pp. 161-188, pls. 11-15, Dec. 10, 1898.)

Ladd, G. E.

Notes on the Cretaceous and associated clays of middle Georgia. (Am. Geol., vol. 23, pp. 240-249, Apr. 1899.)

Leith, C. K.

Summaries of current North American pre-Cambrian literature. (Jour. Geol., vol. 7, pp. 190-205, Feb.-Mch. 1899.)

Marsh, O. C.

On the families of sauropodous Dinosauria. (Geol. Mag., new ser., dec. 4, vol. 6, pp. 157-158, Apr. 1899.)

[Marsh, O. C.]

Othniel Charles Marsh. (Eng. and Mining Jour., vol. 67, p. 349, portrait, Mch. 25, 1899.)

Matthew, G. F., and Kain, S. W.

On artesian and fissure wells in New Brunswick. (Bull. Nat. Hist. Soc. of New Brunswick, no. 17, pp. 143-152, 1899.)

O'Harra, C. C., and Forsyth, A.

Notes on the geology and mineral deposits of a portion of the southern Black hills. (Bull. South Dakota School of Mines, 41 pp., Jan. 1899.)

Orton, Edward.

Geological structure of the Iola gas field. (Bull. Geol. Soc. Am., vol. 10, pp. 99-106, pl. 11, Mch. 6, 1899.)

Pirsson, L. V.

On the phenocrysts of intrusive igneous rocks. (Am. Jour. Sci., ser. 4, vol. 7, pp. 271-280, Apr. 1899.)

Pratt, J. H.

On the occurrence, origin and chemical composition of chromite. (Am. Jour. Sci., ser. 4, vol. 7, pp. 281-286, Apr. 1899.)

Shimek, B.

The distribution of loess fossils. (Jour. Geol., vol. 7, pp. 122-140, Feb.-Mch. 1899.)

Stevenson, J. J.

Our society. [Annual address by the president.] (Bull. Geol. Soc. Am., vol. 10, pp. 83-98, Feb. 26, 1899.)

Turner, H. W.

The granitic rocks of the Sierra Nevada. (Jour. Geol., vol. 7, pp. 141-162, Feb.-Mch. 1899.)

Turner, H. W.

Some rock-forming biotites and amphiboles. (Am. Jour. Sci., ser. 4, vol. 7, pp. 294-298, Apr. 1899.)

Washington, H. S.

The petrographical province of Essex county, Mass. III. (Jour. Geol., vol. 7, pp. 105-121, Feb.-Mch. 1899.)

Weeks, F. B.

The duplication of geologic formation names. (Science, new ser., vol. 9, pp. 490-491, Mch. 31, 1899. Amer. Geol., vol. 23, pp. 266-267, Apr. 1899.)

Weidman, Samuel.

A contribution to the geology of the pre-Cambrian igneous rocks of the Fox River valley, Wisconsin. (A thesis submitted for the degree of Doctor of Philosophy, University of Wisconsin, 1898. 63 pp., 10 pls.; Madison, 1898. Reprint of Wis. Geol. and Nat. Hist. Survey, Bull. no. III, science ser. no. 2.)

Wieland, G. R.

A study of some American fossil cycads. Part. II. The leaf structure of Cycadeoidea. (Am. Jour. Sci., ser. 4, vol. 7, pp. 305-308, pl. 7, Apr. 1899.)

Winchell, N. H.

The optical characters of jacksonite. (Am. Geol., vol. 23, pp. 250-251 Apr. 1899.)

Wolff, J. E.

On hardystonite, a new calcium-zinc silicate from Franklin Furnace, New Jersey. (Proc. Am. Acad. Arts and Sci., vol. 34, no. 18, pp. 477-481, Apr. 1899.)

Woodman, J. E.

Geology: north shore [near Boston, Mass.]. (Guide to localities illustrating the geology, etc., of the vicinity of Boston, pp. 9-20. A. A. A. S., 50th anniversary meeting, Boston, August, 1898.)

Woodman, J. E.

Studies in the gold-bearing slates of Nova Scotia. (Proc. Boston Soc. Nat. Hist., vol. 28, no. 15, pp. 375-407, 3 pls, Mch. 1899.)

Woodman, J. E.

Ore-bearing schists of middle and northern Cape Breton. (39 pp.: reprinted from Rept. Dept. of Mines, Nova Scotia, for year ending Sept. 30, 1898; Halifax, Mch. 1899.)

Wright, G. F.

The truth about the Nampa figurine. (Am. Geol., vol. 23, pp. 267-272, Apr. 1899.)

CORRESPONDENCE.

COLLECTING FOSSILS IN THE CINNCINATI SHALES.—One of the most striking features of the numerous collections of fossils of the Cincinnati district, examined by me, is the almost total absence of the forms occurring in the shales of that formation. For a long time no adequate explanation suggested itself for this conspicuous absence of the not only beautiful but highly interesting and valuable specimens which almost invariably rewarded my efforts, when a resident collector in that justly famous locality.

The reason which at last suggested itself to me is, that collectors being at a loss as to the proper time in which to work them, and as a consequence having had disappointing results, have come to regard the shales as unprofitable.

Judging from my own experience, they offer advantages to the systematic collector far superior in many respects to the weathered quarry dumps and natural exposures. Surface collecting and the breaking of rock have each its advantage, but to get the best results all should be worked together.

The Pelecypoda of the shales, although occurring chiefly as casts of the interior, are otherwise nearly always found in an excellent state of preservation, especially as regards surface markings, which are often beautifully defined. On the contrary, those found in the soft limestone are with few exceptions so poorly preserved, as to be worthless for study. During the winter of 1895, and the early spring of 1896, I collected in about eight weeks more than one thousand specimens of pelecypods, representing about one hundred and ten species, fully seventy-five per cent. of which were found in the soft shales.

Besides the pelecypods, many species of other classes of fossils were found. Some rare forms of trilobites, crinoids and brachiopods being among them.

The statement that these fossils were collected in the winter time may occasion surprise to some collectors, which is likely to become greater, when I assert that the winter and early spring is the proper season for successful work in the shales.

Of course the winter must be sufficiently open to allow the quarries to be worked. The winter mentioned was of that kind, little snow having fallen and many days being warm and bright.

In speaking of shale collecting, especial reference is had to the lumps of shale taken from their formations in the quarries. These should be allowed to remain for several weeks exposed to the snows and rains, to become thoroughly saturated with moisture. They can then readily be split with a geologist's hammer, or lifted layer after layer, with a strong, pointed knife blade, until each piece has been thoroughly prospected. Following very severe weather, the moisture in them having thoroughly frozen, the outside soon begins to crumble

or slack, and forms a covering of mud, which is for the time being, their protection. This condition naturally deceives the collector, who, forgetting that this covering of mud, has preserved the fossils underlying it from the elements, passes it by, and thus loses what may have proved to be a valuable find. Had this but been known, a different story from collections, deficient in specimens from the Cincinnati shales would have been told. Perfectly fresh shale is at all times difficult to work, being tough and punky, and it is almost impossible to split it with a hammer. During the hot summer months those shales which have been subjected to alternate bakings and soakings, are unfit for satisfactory work. The fossils generally scale, and as a rule are not in the best state of preservation.

These notes are written with the hope that local collectors who have previously been unsuccessful in working the shales may profit by my experience.

Washington, D. C. HENRY E. DICKHAUT.

"THE TRUTH ABOUT THE NAMPA FIGURINE."-In his resurrection of the much-ventilated Nampa image, under the above caption, in the April number of the American Geologist, reverend professor Wright refers to "Mr. McGee, who for so long a time occupied the position of literary censor in the United States Geological Survey" (p. 270). In its relation to the truth, this allegation is of a piece with other statements throughout the argument. The facts—which are largely matters of public record, and are pretty generally known among the geologists of the country—are (1) that throughout the entire period of my connection with the U. S. Geological Survey I was engaged, officially and actually, in original researches in geology, with ancillary work in the preparation of my own results for publication and in the administration of the affairs of my own division of the survey; (2) that during portions of the period I, like several associates, had some advisory connection with the general administration of the Survey; and (3) that, throughout the entire period, my work was of such character as to bring me less censorial duty than fell to the share of most of my associates of corresponding grade.

W J MCGEE.

PERSONAL AND SCIENTIFIC NEWS.

AT HARVARD UNIVERSITY the following appointments have been made: William Morris Davis, professor of physical geography, to be Sturgis-Hooper professor of geology; Robert Tracy Jackson, to be assistant professor of paleontology; Jay Backus Woodworth, to be instructor in geology.

PROF. B. K. EMERSON, during the last winter, has been engaged in bringing together all the data available concerning the granites of Massachusetts and their contact zones. The previous field season was spent among the crystallines west of the Carboniferous Narragansett basin of Rhode Island. He finds the region to consist largely of Cambrian quartzytes and green schists. These are intruded by pre-Carboniferous granites, quartz porphyry, micro-granite, and interesting breccias of aporhyolytes which appear to be a distant continuation of the volcanic activity near the Boston basin.

PROF. DR. ANTON FRITSCH, DIRECTOR OF THE HOF-MUSEUM at Prague and well known from his valuable contributions to zoölogy and palæontology, is making a tour of inspection of the leading universities and museums in this country. He has expressed himself as greatly astonished at the wealth of palæontological material brought together in New York and Boston, especially fossil vertebrates; saying that the collections here far outrank those of any single institution abroad. At Cambridge he was particularly interested in the famous Schary collection, which contains a large number of Barrande's types from Bohemia. Prof. Fritsch's principal work, *Fauna der Gas-Kohle*, of which several volumes are already issued, is now approaching completion. The last part deals with Permian arachnids very similar to those found at Mazon creek, Illinois.

DR. A. C. LANE, WHO HAS BEEN ASSOCIATED WITH DR. L. L. HUBBARD in the Geological Survey of Michigan and has contributed largely to volumes V and VI of the state reports, has been appointed his successor, and the board of control have requested him, with a view to expediting publication, to reside near the state printer in Lansing. In this action they have also had in mind the growing importance of the mining interests in the Lower Peninsula, which is shown by the shipment of coal to Wisconsin from the Michigan coal fields, and the numerous recently erected salt, soda, and cement factories. Dr. Hubbard will not entirely sever his connection with the Survey but will continue to have an oversight of the work in the Copper District.

THE LEGISLATURE OF THE STATE OF WISCONSIN has recently appropriated ten thousand dollars per year for two years to carry on the new "geological and natural history survey" of that state, of which Prof. A. E. Birge of the State University is director.

NEW YORK ACADEMY OF SCIENCES. Section of Geology and Mineralogy, April 17. Dr. A. A. Julien presented a "Note on a Feldspar from the Calumet Copper mine, Keweenaw point, Michigan," with specimens collected by him at the first opening of that mine. The wide distribution of the mineral was pointed out through both the Portage Lake and Ontonagon districts, as drusy linings of cavities in the amygdaloid and in crystals scattered through the cement of the copper conglomerate. The crystals were of simple type, a rhombic prism with orthodome modification on obtuse angles, but both faces and cleavage-planes were often distinctly curved. By the complete analysis presented, it was identified as a normal orthoclase, with an unusually large proportion of protoxides in isomorphous replacement. These seemed to bear a relationship to the instability of the mineral, indicated by its general decomposition ; to its remarkably low specific gravity, 2.455 ; and possibly, in part, to the curvature of its planes.

Prof. J. F. Kemp called attention to the unusual presence of cobalt oxide in a feldspar, shown in the analysis.

Mr. E. O. Hovey gave a very interesting description with lantern illustrations, of "Geological and Mineralogical Notes gathered during a Collecting Trip in Russia," in connection with the excursions of the recent International Congress. Many of the lantern pictures were beautifully colored ; they referred in part to ethnographic observations ; and the accompanying remarks awakened much interest.

SCHOOL OF MINES, UNIVERSITY OF MINNESOTA. The annual trip of the graduating class to some of the mining districts will this year be to the lead and zinc mines at Joplin, Mo., and to the gold district of Cripple Creek, Colorado. The class will be accompanied by professors Appleby, Barneveld and Berkey, and will be absent about a month, leaving Minneapolis May 1st.

PROF. G. C. SWALLOW, who was for many years connected with the University of Missouri, and state geologist both of Missouri and of Kansas, died April 20, at Evanston, Ill., aged 82 years.

PROF. JOHN COLLETT, for many years state geologist of Indiana, died at Indianapolis, on March 15th, aged seventy-one years.

PROF. BENJAMIN F. MUDGE.

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VOL. XXIII, PLATE XII.

THE

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VOL. XXIII. JUNE, 1899. No. 6

PROF. BENJAMIN F. MUDGE.

By S. W. WILLISTON, Lawrence, Kansas.

Plate XII

There is no name connected with the early history of Kansas more widely and generally revered by the people of the state than that of the subject of this sketch. A man of excellent attainments and scholarly culture, of deep and wide sympathies, remarkable enthusiasm and purity of conduct, a most skillful and beloved teacher, he has left an impress second to that of none other in the early history of Kansas. In the senate chamber of the state capitol at Topeka his name occupies a conspicuous tablet among those of a dozen other illustrious names of Kansas. An honor so exceptional to the memory of a modest scientific man finds its explanation in the great personal esteem in which he was held, as well as in the public work he did for the advancement of the interests of the state.

Benjamin Franklin Mudge was born at Orrington, Maine, Aug. 11, 1817, and died at Manhattan, Kansas, Nov. 21, 1879. He was descended from a family of the characteristic sturdy and upright New England type. His grandfather, Enoch Mudge, was one of the sentinels who guarded the old Province House when it was occupied by Washington. His grandmother, Lydia Ingalls Mudge, was the granddaughter of the first white settler of Lynn, Mass. His father, James Mudge, was for many years one of the most prominent men in Lynn, Mass., and a pillar of the Methodist church. "His unbending

integrity, deep piety, sound sense and solid character made him a marked man in the community and in the church." Doubtless these characters in the father explain the traits so conspicuously seen in Benjamin, as well as in his brothers, James, Zachery and Thomas, who were all clergymen, the last named professor of sacred literature in McKendree college, and all more or less noted as scholars and authors. Of the thirteen members of the family, eight reached maturity, and all, but especially the sons, were of studious and scholarly habit from early childhood.

Professor Mudge received his early education in the public schools of Lynn, whither his parents returned while he was yet an infant. He prepared for college in the Lynn and Wilbraham academies. He entered Wesleyan University at Middletown, Conn., in the sophomore year and graduated in the scientific course in 1840. The following year he returned, however, to complete the classical course. While a student at Wesleyan University he first made the acquaintance of Alexander Winchell, the well-known geologist and author, who graduated a few years later at the same institution.

During the time of his preparation for college and later, Benjamin aided his father in his shoe business at Lynn, since the rearing and education of the eight sons and daughters was a not inconsiderable draft upon the family resources, though his father was a man of some considerable means for those days.

After graduation, he entered upon the study of law, and was admitted to the bar of Essex county, Mass., in 1844. He practiced his profession at Lynn until 1859, largely in probate work. During this period he held the offices of mayor of the city of Lynn and associate justice of the police court. An ardent, but by no means unreasonable advocate of temperance throughout his whole life it was upon this issue that he was made mayor. The following, from a Lynn paper published at the time of his election to the office might have been said of Mudge at any period of his life with entire truth: "He is openly and unequivocally on the side of temperance and morality; his example is such as any father may hold up to his son to follow; his qualifications are undoubted; he will always be at the post of duty, calm, clear-headed and prudent."

During 1859 and 1860 he was employed in the Chelsea, Mass., and Breckenridge, Ky., oil refineries as chemist. In 1861 his pronounced anti-slavery views and his warm sympathetic interest in the cause of freedom induced him to give up his position in Kentucky and remove to Wyandotte (now Kansas City), Kan. For two or three years he was engaged in teaching there, and immediately became well and favorably known as a lecturer. In 1864 having given by invitation a lecture before the state legislature upon the geological resources of his adopted state, he was unanimously appointed state geologist. This position he held for a single year, when he was elected professor of natural history in the Kansas Agricultural College, at Manhattan, then the foremost educational institution in the state. During the eight years incumbency of this professorship he held at different times the office of president of the State Teachers' Association and of the Kansas Academy of Science, of which he was the principal founder. In 1873, on account of the reorganization of the agricultural college and the assumption of its presidency by a well-known politician unfitted for such a position, Prof. Mudge resigned his place, and up to the time of his death was more or less actively engaged in field work for Yale College and the Kansas State Board of Agriculture. He was also, during part of this time connected with the state university as lecturer on geology.

From his earliest boyhood professor Mudge had been deeply interested in natural science studies, especially mineralogy, geology and botany. His tastes in this direction were pronounced during his college work, and his active collecting habits, which persisted throughout his whole life, seemed to have been begun at this time. During all of his professional practice his interest in these subjects never abated. While at Lynn his now large collections in geology and mineralogy were deposited in the Lynn Natural History Society of which he was one of the active organizers and for years curator. It was at this time that he made the acquaintance of Othniel C. Marsh, at that time a young man interested in the study of mineralogy. He aided him materially in his studies and in his collections. In fact one of the most pronounced characteristics of professor Mudge was his unfailing interest in and sympathy with young and struggling students. His hearty words of en-

couragement and oftentimes material assistance in other ways have been the foundation or turning points in the careers of not a few who have since achieved more or less prominence as scientists.

In Kansas his scientific work was largely that of an explorer. Arduous, intrepid, willingly undergoing hardships and dangers for the sake of science, he explored a very large part of Kansas when explorations meant real dangers and hardships of the most pronounced kind. As early as 1870 he made explorations into the extreme western part of the state in the study of its geology and paleontology, and for years afterward, nearly every summer found him in the midst of the Indian country usually wholly without protection from the danger of hostile Indians save such as his own rifle and revolver afforded. In the summer of 1874, with but two assistants he explored the whole length of the Smoky Hill river, an utterly trackless wild infested by Indians, whose murderous depredations were visible on every side.

Professor Mudge's published scientific work is not extensive. Knowledge that he acquired, and which he might have given to the world himself, he freely intrusted to others for publication, largely through his own modesty, partly because he believed that the better facilities of others would enable them to do the work more thoroughly and better. His generous unselfishness in scientific matters, as in everything else, prompted self abnegation for the greater benefit of his dearly beloved science. So long as his numerous scientific discoveries added to the stock of human knowledge he seldom cared who gave them to the world. His extensive collections in the whole field of Kansas geology and paleontology have greatly enriched scientific literature. Especially will his name be found with great frequency in the published works of Lesquereux, White, Cope and Marsh as the discoverer of very many of the new forms described by them. It was on one of his early trips in the western part of the state that he discovered the now famous specimen of Ichthyornis, the first specimen of a toothed bird ever found showing the presence of teeth. This specimen yet remains perhaps the most perfect specimen of the smaller toothed birds in any collection. It was practially presented to Prof. Marsh, and furnished this author the material from which

he suddenly became famous. His extensive collections of mineralogy and paleontology were presented to the Agricultural College, but, unfortunately, from lack of appreciation by the political head of that institution a large part of the "bones and stones" that he had so painfully collected were destroyed or thrown out into the yard after his resignation.

And yet, professor Mudge published not a few important contributions to the geology of Kansas, especially in his later years, which will be found chiefly in the Transactions of the Kansas Academy of Science the Kansas State Board of Agriculture, and the Bulletins of the United States Geological Survey of the Territories, together with numerous articles in the more popular periodicals. Mudge made the first geological map of the state, which is fairly correct in its main features, save for the Lower Cretaceous, which he did not recognize. He mapped and described with tolerable accuracy and fullness the physical structures of the different Cretaceous and Tertiary horizons, and gave at length general descriptions of their stratigraphic features. Much if not most of the information thus given was based upon his patient researches in wagon and on foot. In general it may be truthfully said that his pioneer work in Kansas geology was important and extensive, though now largely superseded by more detailed and accurate studies. He saved the people of his adopted state many thousands of dollars by his skilled advice, so freely given that he died a comparatively poor man.

His work in life, however, has chiefly borne fruit as a teacher. He was widely known as an enthusiastic and able lecturer, and his courses were always in demand by the teachers and scientific men of the state. His quiet modesty and unselfishness disarmed all envy and jealousy. Of most charming personality, of wide culture and unbounded enthusiasm his teachings made an unusual impression upon all with whom he came in contact. In his later years, the kindly faced, plain old gentleman, as ready to talk with the uncouth farmer as with the aristocrat, interested in everything that affected human happiness or human morals, was known from one end of the state to the other, a welcome guest everywhere; and while his enthusiastic eagerness in the discovery of a new fossil or a new fact in geology might occasionally bring a smile to the unscientific,

he was loved and revered by the people of Kansas as perhaps no other citizen has ever been.

Especially is his memory held in high esteem by his pupils. His kindly reproofs of every thing that was wrong only endeared him the more to them. His unquenchable enthusiasm, his warm and unending interest in their work have made an impression upon the many hundreds of pupils that received instruction from him that can never be appreciated. The writer, especially owes to him a debt of gratitude that is boundless. He was his pupil in school for five years and his assistant in the field for two years more. Never in all his life has he met a man whose absolute purity of deed and word would compare with his. A total abstainer from all vices, a widely cultured man, and one whose nobility of character was equalled only by his love for science, he has left as a heritage a name emblazoned high in the history of Kansas. In the words of Dr. C. A. White, published at the time of his death "he was a sincere devotee of science, and an intelligent interpreter of nature, and better still, an honest man. Peace to his ashes."

Professor Mudge was married in 1846 to Miss Mary E. A. Beckford, who yet survives him with two sons and a daughter. A plain shaft built of the different ornamental stones of the state, which he himself had brought to light, and reared under the auspices of the Kansas Academy of Science, marks his last resting place at Manhattan.

Chronological List of Benjamin F. Mudge's Scientific Papers.

1. First Annual Report on the Geology of Kansas by the State Geologist. 12mo, pp. 56. Lawrence, Kansas, John Speer, State Printer, 1866.

2. Discovery of Fossil Footmarks in the Liassic (?) Formation of Kansas. Amer. Journ. Sci., xii, pp. 174-176, 1866.

3. On a Meteorite which exploded over Kansas, June 6, 1866. Amer. Journ. Sci., xvi, pp. 429, 430, 1868.

4. Red Sandstone of Central Kansas. Trans. Kans. Acad, Sci., i, pp. 394-396, 1872.

5. Geology of the Arkansas. Trans. Kans. Acad. Sci., i, pp. 408-410, 1872.

6. Traces of the Mound Builders in Kansas. Trans. Kans. Acad. Sci., ii, pp. 5, 6, 1873.

7. Recent Discoveries of Fossil Footprints in Kansas. Trans. Kans. Acad. Sci., ii, pp. 7-9, 1873.

8. Geology of Kansas. Annual Report, Kans. State Bd. Agric., pp. 102-107, 1874.

9. Geological Survey of Kansas. Trans. Kans. Acad. Sci., iii, pp. 342-344, 1874.

10. Pliocene Tertiary of Western Kansas. Trans. Kans. Acad. Sci., iii, pp. 351-353, 1874.

11. Rare Forms of Fossil Fish in Kansas. Trans. Kans. Acad. Sci., iii, p. 356, 1874.

12. Geology of Kansas, Fourth Ann. Rep. Kans. St. Bd. Agric., pp. 107-127, 1875.

13. Annual Report of the Committee on Geology for the year ending November 1, 1876. Trans. Kan. Acad. Sci., v, pp. 4, 5, 1876.

14. Bison latifrons in Kansas. Trans. Kans. Acad. Sci., v. pp. 9, 10, 1876.

15. Notes on the Tertiary and Cretaceous Periods of Kansas. Bull. U. S. Geol. Surv. of the Terr., ii, pp. 211-221, 1876.

16. The Same, with Additions. Ninth Ann. Rep. U. S. Geol. Surv. of the Terr., pp. 277-294, 1877.

17. Flesh Fossilization an Impossibility. Kans. City Review Sci., i, pp. 484, 485, 625, 626, 1877.

18. Geology of Kansas. First Biennial Rep. Kans. St. Bd. Agric., pp. 46-88, 1878.

19. Cretaceous Forests and their Migration. Trans. Kans. Acad. Sci., vi, pp. 46, 48, 1878.

20. Internal Heat of the Earth. Trans. Kans. Acad. Sci., vi, pp. 49-51, 1878.

21. Fossil Leaves in Kansas. Kans. City Rev. Sci., ii, pp. 604-606, 1878.

22. Economical Geology. Second Biennial Rep., Kans. St. Bd. Agric., pp. 63-75, 1879.

23. The New Sink hole in Meade Co. Kans. City Rev. Sci., iii, pp. 152-153, 1879.

24. Another View of the Antiquity of Man. Kans. City Rev. Sci., iii, pp. 222-224, 1879.

25. Are Birds derived from Dinosaurs? Kans. City Rev. Sci., iii, pp. 224-226, 1879.

26. Botany and Evolution. Kans. City Rev. Sci., iii, pp. 257-263, 321-328, 1879.

27. Are the Indians decreasing? If so, Why? Kans. City Rev. Sci., iii. pp. 385-391, 1879.

28. Man and Evolution. Kans. City Rev. Sci., iii, pp. 615-623, 1880.

29. List of Minerals found in Kansas. Trans. Kans. Acad. Sci., vii, pp. 27-29, 1880.

LEWINSON-LESSING'S CLASSIFICATION OF ROCKS AND DIFFERENTIATION OF MAGMAS.

NOTE.–The following review of a recent important Russian contribution to the subject of classification and differentiation will make available to English-speaking geologists the views of a Russian savant whose opinions are otherwise nearly inaccessible. The writer has simply translated it from the French and hereby wishes to express to the young petrographer his thanks for the thorough examination of the work which the review itself testifies to, and his regret that the reviewer's modesty has enjoined him from appending the reviewer's name to the communication. N. H. W.

GENERAL PETROGRAPHY.

Theoretical Part. Chapter I.

The first chapter of the work is devoted to the chemical classification of eruptive rocks. In the historical sketch there should be added, to the sketch of the views of Roth, Iddings, Michel Levy, etc., an exposition of the work of Schröckenstein, published in 1886 under the title: Ausflüge auf das Feld der Geologie. Geologischen Sudien der Silicatgesteine. Schröckenstein has taken for base of his classification of eruptive rocks the degree of acidity (silicatstufe) of the silicates, and by analogy from these he establishes the principal types of eruptive rocks.

The new classification of Lewinson-Lessing is based essentially on the same idea. However, the author states that he had no knowledge of the work of Schröckenstein until after he had completed a portion of his computations.

In order to characterize an eruptive rock from the point of view of its chemical composition the author proposes to make use of the following properties:

1. Degree or coefficient of acidity. α. By dividing the number of atoms of oxygen held by SiO_2 by the number of those which are contained in the other oxides, a characteristic number (α) is obtained. In averaging each family is found to have its coefficient.

2. Formula of chemical composition. The oxides are put in two groups, RO* and R_2O_3. Taking as unity the quantity of that group whose content is smallest, he obtains the formula of

*RO equals the sum of K_2O, Na_2O, CaO, MgO, FeO.

the type: mRO, R_2O_3, $n SiO_2$. Generally each family and each type has a characteristic formula.

3. The relation between R_2O and RO in molecular proportions.

4. The relation of Na_2O to K_2O in alkaline rocks.

In order to obtain the formulas and the numbers of the table the author computed the results of 345 analyses of rocks taken principally from the following works:

F. Zirkel: Lehrbuch der Petrographie, 1894.

H. Rosenbusch: Ueber die chemischen Berichtungen der Eruptivgesteine.

C. Brögger: Die Eruptivgesteine des Kristianiagebietes.

W. Cross. The laccolitic mountain groups of Colorado, Utah and Arizona. U. S. G.S., 1894, etc. [Table is on pp. 350-351.]

Without direct reference to these works, an analysis made by the author may be taken as an illustration of his method of calculation. M. Lewinson-Lessing states that the chemical composition of the rock, expressed in the percentages of silica and of the different oxides, is not well characterized. In order to obtain the four properties mentioned (above) which in his opinion are characteristic he proceeds as follows: He divides the quantity, expressed in percentage of each oxide (SiO_2 R_2O, RO, R_2O_3) which is given by the analyses, by the corresponding molecular weight; the quotient, called by him the "molecular proportion," or equivalent quantity, is a characteristic number.

Let us take as an example the diabase of Assa (Caucasus), p. 374 and 385 of the text.

	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	Total
Per Cent	49.19	16.83	1.96	8.15	12.38	7.50	trace	3.24	99.25
Molecular Weight	60	102	160	72	56	40		62	
Quotient of 1st by 2d	.828	.166	.012	.114	.222	.189		.050	

Hence: as RO equals R_2O+RO equals FeO+CaO+MgO+K_2O+Na_2O, and

R_2O_3 equals Al_2O_3+Fe_2O_3,

SiO_2 equals 0.83; RO equals 0.575 (equals 0.58) and R_2O_3 equals .178 (equals 0.18).

Multiplying the coefficients by 10 we obtain the formula:

$$5.8RO,\ 1.8R_2O_3,\ 8.3SiO_2$$

Taking the quantity of the smallest group (1.8) and dividing the coefficients we get the final formula of the diabase, viz.:

$$3.2RO,\ R_2O_3,\ 4.61SiO_2.$$

The coefficient of acidity, α, equals

$$\frac{\text{O of } SiO_2}{\text{O of the other oxides}} \text{ equals } \frac{9.22}{6.2} \text{ equals } 1.49$$

$$\frac{\text{Oxygen of } SiO_2 \text{ equals } 4.61 \times 2 \text{ equals } 9.22}{\text{Oxygen of the other oxides equals } (3.2 \times 1) + 3 \text{ equals } 6.2}$$

equals 1.49.

RO (properly) equals FeO+CaO+MgO equals 0.525.

The relation of R_2O:RO equals 0.052÷0.525 equals $\frac{1}{10}$

Lewinson-Lessing has added at the end of his book the tables showing the quotients, as above obtained, of 345 analyses. If comparison be made of the formulas of the granites, for example, with the formula RO, R_2O_3, $7.7SiO_2$ of the table of classification, it becomes apparent that it is a medium formula. It is the same also for the coefficient of acidity. The author says that the error does not exceed from 0.1 to 0.2 for α Water is not considered amongst the oxides of RO.

Characteristics of the principal groups.

The author thus characterises the principal groups:

I. *Hypo or ultra basic rocks*: Predominance of monosilicates; total absence (or in great part) of the feldspars; absence of free silica; $\alpha > 1.4$. He finds that the place assigned to limburgyte in the classification, i. e., between peridotyte and basalt with nepheline and leucite, satisfies equally mineralogical and geological petrographers.

II. *Basic rocks*: Importance of the bisilicates; presence of the plagioclases, of leucite or of nepheline; absence of free silica; frequent presence of olivine; according to the author the coefficient of acidity α approaches that of the phonolytes and of the syenites with eleolite, and of the basalts, which explains the presence of olivine in certain eleolite syenites. It is the same type of magma as the basaltic. The only difference is

this: that the alkalies predominate in the magmas of the eleolitic syenites, which are more acid than the basalts, in which the alkaline earths predominate.

III. *Neutral rocks*: Absence of olivine, nepheline, of leucite; predominance of the bisilicates and the most acid feldspars with sometimes a small amount of free quartz. The rocks of this group have nearly all the same formula. The coefficients(α) have also very nearly the same value. The relation $R_2O:RO$ alone distinguishes them. Lewinson-Lessing ascribes them to metamorphism of earlier rocks.

IV. *Acid rocks*: Great quantity of free quartz; predominance of the most acid feldspars, and a relatively feeble rôle of the bisilicates. i. e. of mica; for coefficient of acidity the limits are from 2.5 to 4.5 or 5. In certain keratophyries α runs from 6 to 7 but in that case the author supposes there has been a deposition of free secondary quartz. Certain petrographers, Rosenbusch for example (and Lewinson-Lessing formerly), consider an acid magma to be a neuter or basic magma with added quartz– *e. g.*, granite equals syenite+quartz; quartz-dioryte equals dioryte+quartz. That is correct from a mineralogical point of view, but faulty from a chemical point of view. Granite, for instance, is not alone richer in SiO_2 than syenite, but the relations of $R_2O:RO$ and $RO:R_2O_3$ are also different.

Relations between Different Oxides and Groups of Oxides.

Are there distinct types of fundamental magmas? Rosenbusch replies *yes* to this question and distinguishes five or six principal types. Lewinson-Lessing distinguishes many more —but before entering upon that subject it is appropriate to ask what should be the distinguishing characters of these principal magmas. Lewinson-Lessing considers as a distinctive sign of a chemical type of a magma "an independent difference," but not a parallel difference, so to speak. For example, if in two groups of rocks, one more rich in a constituent part a and the other poor in a there is the same relation toward a constituent part b. The differences are parallel, as used by the author.

	I Group	*II Group*
Differences parallel and direct.	m a	n a and $m>n$
	x b	z b and $x>z$

TABULAR CLASSIFICATION OF ERUPTIVE ROCKS.

Principal Groups.	Sub-Groups.	Families.	Formulas.	Coefficients of Acidity.	Relation R_2O: RO.	Sub-Divisions.
(A)	I. Magma aluminous with sesquioxides.	1. Kyschtymyte.	3.5 RO, R^2O^3, 2.1 SiO^2	0.35	1: 7	
HYPO-BASIC ROCKS.	II. Magma alkalineearthy without or nearly without alumina.	2. Peridotyte.	12.1RO, R^2O^3 8SiO^2	1.17		
Monosilicate Magma.		3. Basalt with melilite.	6.3RO, R^2O^3, 4.9 SiO^2	1.03	1:12.7	
$\alpha < 1.4$	III. Magma intermediate with more or less alumina.	4. Limburgyte (and augityte).	2.2RO, R^2O^3, 3SiO^2	1.14	1: 5.6	
		5. Camptonyte.	1.5RO, R^2O^3, 2.8 SiO^2	1.25	1: 4.1	
		6. Basalt with nepheline, basanite.	2.5RO, R^2O^3, 3.5 SiO^2	1.20	1: 3.6	
		7. Basalt with leucite, basanite.	1.9RO, R^2O^3, 3 SiO^2	1.21	1: 4.6	
		8. Monchikyte (I type).	2.3RO, R^2O^3, 3.2 SiO^2	1.20	1: 3.7	
	IV. Magma alkaline.	9. Urtyte.	1.1RO, R^2O^3, 2.51SiO^2	1.21	6: 9.1	
(B)	V. Magma without or nearly without alumina.	10. Pyroxenyte and amphibolyte.	29.6RO, R^2O^3, 29.6SiO^2	1.83		Alkaline-earthy, alkaline.
BASIC ROCKS.		11. Schonkinyte.	5.RO, R^2O^3, 6.4SiO^2	1.60	1: 7	Limy (gabbro proper); magnesian (noryte, hypersthenyte); akalino-magnesian (missowyte schronkinyte); alkaline (leucityte, iolyte)
Bisilicate (or 1½ silicate) Magma.		12 Gabbro.	3RO, R^2O^3, 4.2SiO^2	1.45	1:15	
$2.2 > \alpha > 1.4$		12 Noryte, hypersthenyte.	2RO, R^2O^3, 4.3SiO^2	1.71	1: 8.2	
		12 Diabase.	2.5RO, R^2O^3, 4.2SiO^2	1.62	1: 6.2	
	VI. Magma alkaline, earthy.	12a. Basalt.	2.6RO, R^2O^3, 4.6SiO^2	1.63	1: 7.8	Alkaline-earthy; alkaline (basalt with orthoclase in part, leucityte and nephelinyte).
		13. Monchikyte (II type).	2.2RO, R^2O^3, 4SiO^2	1.5	1: 2.5	
		14. Melaphyry.	2.3RO, R^2O^3, 5.1SiO^2	1.9	1: 3.6	
		15. Dioryte.	1.5RO, R^2O^3, 4SiO^2	1.77	1: 4.3	
		16. Gabbro-syenite.	3RO, R^2O^3, 6SiO^2	2.0	1: 3.9	

	VII. Magma intermediate.	17. Trachytyte.	1.25RO, R^2O^3, 3.4SiO^2..	1.79	1: 1.1	
		18. Andesyte-trachyte.	1.4RO, R^2O^3, 4.46SiO^2..	2.07	1: 1	
	VIII. Magma alkaline.	19. Syenite with eleolite	11.1RO, R^2O^3, 4SiO^2....	1.92	3. 2:1	
		19a. Phonolyte.	RO, R^2O^3, 4SiO^2.......	2.0	4. 5:1	
		20. Tinguayte.	1.27 RO, R^2O^3, 4.47SiO^2	2.0	6: 1	
(C)	IX. Magma alkaline, earthy.	21. Andesyte.	1.7RO, R^2O^3, 5.2SiO^2..	2.20	1: 2.8	Alkaline-earthy, alkaline (tephryte).
NEUTRAL ROCKS.		22. Porphyryte.	1.4RO, R^2O^3, 5.4SiO^2..	2.4		
Bisilicate or normal magma.	X. Magma intermediate.	23. Syenite.	1.8RO, R^2O^3, 5.6SiO^2..	2.34	1: 2.2	Alkaline (K_2O Na_2O), alkaline-earthy, quartzose.
$2.5 > \alpha > 2$	XI. Magma alkaline.	24. Tephryte.	1.4RO, R^2O^3, 4.9SiO^2..	1.18	1. 5:1	Potassic, Sodic.
		25. Orthophyry.	1.7RO, R^2O^3, 5.3SiO^2..	2.21	1: 1.4	Potassic, Sodic.
		26. Trachyte.	1.25RO, R^2O^3, 5.2SiO^2.	2.42	1: 1.1	Alkaline (K_2O, Na_2O), alkaline-earthy, quartzose.
	XII. Magma alkaline earthy.	27. Quartz trap.	1.7RO, R^2O^3, 5.8SiO^2..	2.40	1: 2.8	
		28. Quartz dioryte.	1.5RO, R^2O^3, 6.4SiO^2..	2.8	1: 2.4	
		28a. Andesite dacyte.	1.6RO, R^2O^3, 5.85SiO^2.	2.50	1: 3	
(D)	XIII. Magma intermediate.	29. Dacyte.	1.25RO, R^2O^3, 6.33SiO^2	3.02	1: 1.5	
ACID ROCKS.		29a. Quartz porphyryte.	1.25RO, R^2O^3, 6.33SiO^2	3.0	1:1.12	
		30. Granite with plagioclase (equals adamelyte or intrusive dacyte).	1.25RO, R^2O^3, 6.69SiO^2	3.36	1: 1.5	
Polysilicate magma.		31. Nordmanyte.	1.1RO, R^2O^3, 5.6SiO^2..	2.68	4. 5:1	
$\alpha > 2.4$ (or 2.3)	XIV. Magma alkaline.	32. Pantellaryte.	1.8RO, R^2O^3, 8.8SiO^2..	3.54	1. 6:1	Alkaline-earthy, alkaline (K_2O, Na_2O).
		33. Granite.	RO, R^2O^3, 7.7SiO^2.....	3.91	1. 7:1	
		34. Quartz porphyry.	RO, R^2O^3, 9SiO^2.......	4.55	2. 5:1	Potassic, Sodic, with ægerite.
		34a. Liparyte.	RO, R^2O^3, 9SiO^2.......	4.76	6. 4:1	Potassic, sodic, ferro-sodic, with ægerite.

But if we have

	I Group	*II Group*	
Differences independent and inverse	m a	n a	m>n
	x b	z b	x<z

If, in passing from one group to the other the quantity of the body a increases in proportion as the quantity b diminishes, this relation is sufficient to establish the independence of two magmas.

To make this clear:

If b is a function of a, b may equal f (a) and especially a decreasing function (that is, varying in a direction contrary to the variable). The author considers this relation as sufficient to establish a chemically independent type of magma. But when b is an increasing function (that is varying in the same direction as the variable) b equals $\rho(a)$, this relation, which he calls parallel or correlative, as employed by the author for the sub-divisions. The choice is arbitrary.

Starting with these ideas the author constructs curves. (See first, Table III at the end of the book, and especially a portion of this table carrying a Roman numeral II. There is a singular disorder in these tables and in the references.)

In order to construct these curves the author places upon an axis of x's the molecular proportions of SiO_2 (i. e., the numbers obtained from analyses in the manner of 0.828 above for the diabase of Assa) and on an axis of y's the molecular proportions of the different oxides whether grouped as in the curves II or separately as in the other curves. The aspect of these curves suggests to him conclusions which are enumerated below. It is necessary to remark, here, that on the square-ruled paper employed one side of a square corresponds, on the axis of the x's to 0.01 of SiO_2 expressed in molecular proportions, and that 0.1 of the SiO_2 in molecular proportion corresponds to 6. of SiO_2 as expressed in the chemical analyses.

Conclusions derived from the Curves II.

1 The curves are fragments of right lines, with angular points. They differ from those of Iddings in that they express always the quantities of oxides and of SiO_2 expressed in molecular proportions, and not the percentages of the analyses. Then

the quantities of the oxides are not continuous functions of the quantity of SiO_2. But if we neglect the zigzags and consider only the general direction (i. e. that of a right line joining the commencement and the end of each curve) it can be seen that: —the general quantity of the oxides diminishes with the general content of silica; the diminution of RO is rapid; the increase of R_2O is much more feeble. The line R_2O_3 is nearly indifferent; it lowers slightly. If we consider the real lines in zigzag, we see that on these lines the zigzags corresponding to the maxima and the minima of the oxides (RO, R_2O_3, R_2O, R_2O + RO) are repeated periodically; at all the 0.1 of SiO_2 there is a maximum for RO and for R_2O + RO, and a minimum for R_2O and R_2O_3. This general periodicity does not take place with the acid rocks, but *en gros* one can say that the quantities of the different oxides are periodic functions of the content of SiO_2. At the same time it is noticeable that R_2O increases and RO diminishes in absolute value. This periodicity is visible also in the foregoing table of classification.

(*Remark of the reviewer.* I translated almost entire the part relating to the relations of the oxides, but although Lewinson-Lessing makes the qualification that it is *en gros* I avow that his pretended law of periodicity, based on his curves, appears to me so greatly *en gros* that I could scarcely accept it. I have not enough imagination to see the periodic repetition in these curves).

2. The oxides RO and R_2O are antagonistic: the magmas rich in alkalies are poor in alkaline earths and vice versa. The zigzags of R_2O and RO go in opposite directions, except in certain parts of the curves. (a) between the eleolitic syenites and the phonolytes; (b) between the basalts carrying nepheline and those with leucite; (c) between the diorytes and melaphyrs. (d) between the granites and the quartz porphyries. Except the melaphyrs, which are perhaps metamorphosed, these exceptions take place within the limits of the same magma, for instance the quartz porphyries are poorer in oxides than the granites, on account of a higher acidity, but the relations of the oxides between them being the same the two kinds of rocks belong to the same chemical type of magma. Further, the metamorphism of quartz porphyries distinguishes them

from liparytes. The phonolytes and the eleolitic syenites are identical; the diminution of RO and R_2O in the phonolytes and the increase of R_2O_3 is explained perhaps by the metamorphism of the eleolitic syenites. There are also similar relations between the leucitic basalts and the nephelinic. Aside from those four groups it is found that the alkalies and the alkaline earths are antagonistic, and the differences of their respective quantities in the rocks can be used to characterize the chemical types of the magmas.

3. The variation of the sum (R_2O + RO) depends on RO, except in one small portion between the andesytes and the syenites–the zigzags of two lines viz.: of RO and of (R_2O+RO) are turned in the same direction.

4. The line of R_2O_3 follows the line R_2O (except the four parts mentioned above, viz.: leucitic and nephelinic basalts, diorytes, melaphyrs, etc.) On the contrary the zigzags of R_2O_3 and of RO are turned in opposite directions (except for the acid rocks and the orthophyrs, andesyte and syenite). Therefore when the magma is separated into two the oxides R_2O_3 (and notably Al_2O_3) follow the alkalies and are antagonistic against the alkaline earths.

5. From what precedes it results that R_2O_3 and(R_2O+RO) are antagonistic except in the acid rocks and the portion of orthophyrs, andesytes.

Conclusions drawn from the Curves I of Table II.

(1) The variations in the quantities of Na_2O and K_2O are in the same direction, except in the granites, quartz porphyries, liparytes, andesytes, syenites and dacytes, and the ultra basic rocks with leucite and nepheline.

(2) K_2O is antagonistic with CaO and MgO;—therefore in differentiation K_2O shares in a different "noyau" (Rosenbusch) from CaO and MgO.

(3) Na_2O also is antagonistic against CaO and MgO, except in the acid rocks; as to CaO there are also two or three exceptions.

(4) Al_2O_3 is antagonistic against CaO except in the ultra basic rocks; in the same way it is antagonistic with MgO most frequently.

(5) The variations of the quantities of CaO and MgO are

usually in the same direction, but sometimes (in the basic rocks) they are in opposite direction—then the subdivision could be characterized by the use of the relation CaO:MgO.

Curves v, Table III. These are constructed by taking as independent variable the coefficient α and placing upon the axis of the y's the corresponding molecular proportions of the different groups of oxides. With two exceptions, *a–b* and *i–l*, the preceding statements are again found applicable:—the (R_2O +RO) and RO are depressed and those of R_2O and R_2O_3 rise. (In fact between the abscissas *t* and *v* the lines R_2O and R_2O_3 are parallel to the axis of the x's). Antagonism appears between R_2O and RO, etc. Here may also be noted, on the diagram xvii, table II, the parallelism of the variations of R_2O and R_2O_3; the antagonism of R_2O and RO and the independence of the line of SiO_2 with respect to all the other oxides.

(*Remark.* M. Lewinson-Lessing does not say in the text how he constructed the curves xvii, that is to say, what he took for independent variable; however it is apparent that he took RO; but, owing to the carelessness and especially the disorder of the editing, and of the references, and the general presentation of ideas, his book is very tiresome to read.)

From p. 60 to p. 104 of the text is Lewinson-Lessing's characterization of eruptive rocks according to the various diagrams, in the following order: Trachytes (diagrams vi and vii); Andesytes (diag. viii): Syenites (diagram ix); Dacytes (diagram x); Liparytes, quartz-porphyries, pantellarytes (diagram xi); Granites, basalts (diag. xii); Gabbros, norytes (diag. xiii and xiv); phonolytes and eleolitic syenites (diag. xv-xvi); orthophyres; quartz diabases, gabbros, norytes; camtonytes. minettes, kersantytes, mica-diorytes; Tephrytes and leucitytes; Tinguaytes, terchenytes and teralytes; Grorudytes; Nordmarkytes; Schlosbergytes; Lindeytes; Malignytes; Missourytes; Monsonytes; Schonkinytes; Monchikytes. It is not necessary to go into the particulars; further, the author puts great stress on a discussion of the opinions of others. Footnotes show the authors cited. As to his own opinions on different rocks, they are pretty much expressed by means of the table of classification given above, and in the curves that represent them. These curves are constructed in the manner of the curves I and II, and are found in the first three tables, but in a degree of dis-

order which is characteristic of the work. Further, it appears as if the author had not been able to choose conventional colors for the different oxides. The same violet color, for instance, stands sometimes for MgO, sometimes for Al_2O_3, and again for CaO. In the text he indicates curves III, when he is speaking of curves V, etc. Such negligence and disorder of the editorship of any book ought to be severely blamed. Life is short and sufficiently full of trouble even with the reading of necessary and useful things. Authors ought not to so loosely arrange their thoughts, and so carelessly express them as to cause the loss of time in deciphering them. Having said this, I will make the further remark that in the first three tables the zero of the ordinates is not the same for all the lines, apparently as if the author intended to indicate in the diagrams only a series of correlations and not the absolute values of the ordinates.

The conclusions of the first chapter are resuméd by the author himself in the French synopsis joined to the book.

The third chapter is also synopsized in French. Lewinson-Lessing says that the purpose of this article was expressed in the "Note on the classification and nomenclature of eruptive rocks" read to the fourth *international congress of geologists* at St. Petersburg. It will therefore be easy to know what the author believes on this subject. The synoptical table of rocks was also presented at St. Petersburg. In this chapter Lewinson-Lessing says the chemical composition of a rock is independent of every other consideration, while its minéralogical composition is conditioned. He considers the chemical composition as an independent variable, and the mineralogical composition, structure, etc., as functions of that variable. Consequently, according to the author, the classification of eruptive rocks ought to be based at the outset, on the chemical composition, and in accordance therewith should be constructed step by step the principal subdivisions.

Critique by the reviewer. It would seem that, before making classifications of rocks based on their chemical composition, it is necessary to have many more analyses. Instead of this the author has satisfied himself with making computations of the analyses of others. Among these are the analyses taken by Rosenbusch which were made, at least in part, on rocks

more or less decomposed. Is it certain that other analyses are not liable to the same defect? And again, what are the chemical types named olivine-basalt, quartz basalt, boralonyte, camptonyte, lamprophyre, missouryte, ijolyte, nordmarkyte, etc., of which the formulas are established on the basis of a single analysis? It is possible, and even probable, that there exist definite chemical types of eruptive rocks, and that they are not mixtures in accidental proportions, but there are no positive proofs of this, for there have not been made a sufficient number of good analyses of rocks from different regions. i. e., of rocks that are absolutely fresh and susceptible of comparison from a mineralogical standpoint. So long as this is not done chemical classifications will be built upon the sand, and will not have any actual value, being simply premature tentatives. This is as much applicable to that of Lewinson-Lessing as to that of all others. It seems to be necessary to insist on this, on account of the exorbitant pretensions of chemical classifications. MM. Michel-Lévy and Fouqué, and Lacroix (Enclaves des Roches) have several times expressed the idea, in connection with their mineralogical classification of rocks, that this classification, based upon facts, (structure, mineralogical composition) has to do with the establishment and grouping of the types of rocks. These types, established by means of the microscope, the only instrument as yet giving exact results, can be grouped in a different manner, according to theories of age, of genesis, of chemical composition, etc. The mineralogical classification therefore makes very modest pretensions. On the contrary Lewinson-Lessing (and according to his historical sketch all others who have advanced chemical classifications) affirms that chemical composition only can indicate the intimate and actual relations between different types of rocks, that the chemical composition is the independent variable, and consequently on it is to be based all classification. The author well states that a rational classification ought to take account of every consideration, but in practice he forgets that, and takes account only of chemical composition. Therefore, while for inorganic bodies chemical composition is the principal property for classification, it is not the only one, and it is necessary to take into account physical properties. If rocks are not arbitrary (or accidental) mixtures, but represent certain fixed

chemical types, no doubt there is also a constancy in their physical properties of which it is also necessary to take account in any rational classification—which, then, ought to be eclectic and not based on a single idea.

Chapter IV. This contains only supplementary notes. The following types are characterized: notyte, kyshtinyte, absarokyte, toskanyte, ciminyte, etc. No comment is necessary on the diagrams of table IV. The circular diagrams are not numerous, and the rectangular diagrams are easy to understand at a glance; they are very clear and represent well the chemical composition. They are similar to those used first by Iddings.

The Differentiation of Magmas. Chapter II.

In a rapid historical sketch the author enumerates the six principal theories, and says that in differentiation it is necessary to take account of: (1.) The principle of Soret. (2.) The principle of the greatest work of Berthelot. (3.) The phenomena that take place in super-saturated solutions. (4.) Phenomena that take place in a mixture of liquids. (5.) The rôle of gravity. He distinguishes between differentiation by crystallization, and magmatic differentiation.

Differentiation by Crystallization.

The principal question is that of the order of succession in which the minerals of rocks are consolidated. At first the author presents the historical exposé of the question and a supplementary note (chap. iv) where he tries to show an accord between the advocates of consolidation by order of fusibility and those who attach importance to the question of super-saturated solutions—since the magma can be considered either as a mixture in igneous fusion or as a super-saturated solution.

Thus, according to the author, from the order of succession of consolidation of the minerals, there can be distinguished three groups: (1.) Rocks in which the order of consolidation follows the rule of Rosenbusch, that is, crystallization commences with the most basic minerals and terminates with the most acid. That is the most usual case. (2.) Rocks in which consolidation takes place in the reverse order: The feld-

spars crystallizing before the ferro-magnesian elements, as in the diabases and basalts. (3.) Rocks with simultaneous crystallization of the feldspars and the ferro-magnesian elements. The experiments of Michel-Lévy and Fouqué have shown that a fused mass held for a long time in a viscous state and quickly cooled crystallizes sometimes totally. That would take place in the third group.

In general it can be concluded that:

(1) The non-silicate minerals are amongst the first to consolidate.

(2) In the rocks "de profondeur," and often in others, the ferro-magnesian minerals crystallized before the feldspars.

(3.) In the diabases and basalts the reverse order takes place.

From these facts Lewinson-Lessing tries to give the law of successive consolidation; and for that purpose he invokes the principle of *maximum work* of Berthelot.

Before this the same principle was applied by A. Harker in the Geological Magazine, 1893, p. 546 and by George Becker in the American Journal of Science 1886, 3rd ser. xxxi, p. 120. Becker says: "The sum of the chemical and physical transformations in any chemically active system will be such as to convert higher form of energy to heat, light, etc., at the greatest possible rate." Hence, according to Becker, the first minerals to be consolidated will be those that by their formation disengage the most heat; but in a magma in process of crystallization heat is produced, first, by consolidation, second, by chemical reactions that accompany the formation of the mineral.

Lewinson-Lessing takes advantage of these ideas in the following manner: During consolidation most bodies lose heat and diminish in volume (water excepted). We will call:

V the actual specific volume of the mineral=the quotient of the molecular weight by the specific weight of the mineral.

v', the theoretical specific volume of the mineral according to the elements=the sum of the atomic volumes of all the atoms entering into the formula of the mineral.

v, the theoretical specific volume according to the oxides =the sum of the volumes of all the oxides (including SiO_2) which compose the mineral.

We have always $V > v'$, and further, according to the calculations of Lewinson-Lessing, we $V > v$.

Therefore, starting with the oxides, when a compound mineral (a silicate) forms in the magma, there results sometimes an increase and sometimes a diminution in volume, and the percentage of this variation varies with the mineral. The greater the diminution of volume the greater the work produced, and consequently the greater the amount of heat disengaged. Therefore according to the principle of maximum work, those minerals which diminish most in volume in forming ought to consolidate first.

Suppose $100V \div v$ equals x, and let y be the quantity of heat disengaged corresponding to the variation of volume x. We shall have y equal f (x); but this function is not known.

The author has calculated the value of V, v, v', and $V \div v$ for a certain number of minerals, using analyses and specific weights comprised in Dana's Mineralogy of 1892, according to which he calculated the formulas of minerals. The atomic volumes and the specific weights of the elements were taken from the chemistry of Mendelejeff and from the tables of Landolt.

Following is the table of these values (V, v, v') including the specific gravity (S), reproduced from the author's text, p. 138.

From this table the author concludes: $V > v$ for the feldspars, leucite, nepheline, etc., and for the ferro-magnesian elements $V < v$. That is to say, the latter on consolidation are accompanied by a diminution of volume, while the feldspars solidify with increase of volume (like water). For all minerals $V < v'$, but for the feldspars the diminution is less than 50 per cent., while for the ferro-magnesian elements it exceeds 50 per cent. Now, according to the laws of thermo-dynamics, the point of solidification rises or falls with the pressure.

	Specific Gravity S	Theoretic specific volume v'	Theoretic specific volume v	Actual specific volume V	$\frac{V}{v}$	Per ct. of units of actual volume
hoclase	2.56	380	196	217	1.1	57
ite (Dana 327)	2.62	404	185	200	1.08	49.5
orthite (Dana 357)	2.758	179	89	100	1.13	55
icite		352				41
eite		308				56.1
radorite (Dana 357)	2.7003	978.2	418.65	464		47.4
artz	2.6	44	22.50	22.6	1.00	51.3
opside (Dana 390. 6)*	3.3(3.2)	116.46		67.4		58
emolite (Ibid., 7)*	3.0	304.15		142.7		46.9
opside (Dana 390. 10)*	3.249		74	66	0.89	
alite (Ibid., 11)*	3.003		248.5	243	0.97	
roxene (Dana 391)	3.187		64	74	1.15	
gnetite (Fe_3O_4)	4.9-5.2	85.6		47.3-44.6	(3)	53.7
matite (Fe_2O_3)	5.24	62.4		30.5		48.8
rundum (Al_2O_3)	4.0	70		25.5		36.4
tile	4.25	41.4		18.8		45.4
con	44-47	98	44	41.3-39.1	0.91	41
statite (Dana 11)	3.27	132.98	35.33	34.1	0.96	25
vine (Dana 7)		104	44.5	43 8	0.98	42
gite (Dana 66a)	3.35	159	76.6	67.5	0.88	41
ucite	2.479	292	151	175	1.15	
liophyllite	2 5-2.6		106	126 (122)	1.18 (1.15)	
pheline ($Na_2O, Al_2O_3, 2 SiO^2$)	2.55-2.65		95	111 (107)	1.16 (1.12)	
pheline($3Na_2O,K_2O,4Al_2O_3,9SiO_2$)			413.5	481	1.16 (1.10)	
vine (Forsterite, Dana 541.7)			44.5	43	0.96	
llastonite	2.9		40.5	40	0.98	
statite	3.2		33.5	31.2	0.93	
opside	3.2-3.3		74	67.5 (66.4	0.91(0.89)	
emolite	3.1-2.9		141	133 (143)	0.94(1.01)	
crocline (Dana 323. 1)			106	214	1.09	
desine (Dana 327)	2.694		274	297	1.08	
desine (Ab_1 An_1)			137	148.5		
eite	2.33		140	173	1.22?	

Considering the formula (called in France the "third formula of Clapeyron").

$$L \text{ equals } (T \div E) \times (u'-u) \times (dp \div dT).$$

$$\text{Whence } (dp \div dT) \text{ equals } EL \div [T(u'-u)].$$

Here L=the latent heat of transformation; T=the absolute temperature; u=the initial volume and u'=the final volume of the body.

The sign of $(dp \div dT)$ depends on $u'-u$.

If u' is greater or less than u, so $dp \div dT$ is greater or less than 0.

For $u' > u$, increase of pressure raises the temperature of

fusion; for $u' < u$, it lowers the point of fusion (as for water).

Lewinson-Lessing supposes that in the fused magma the minerals exist in the state of separated oxides—SiO_2, Fe_2O_3, Al_2O_3, K_2O, etc. When these oxides unite to form silicates the pressure which pervades the depths of the earth is favorable to the formation of minerals of the ferromagnesian order which are formed with a diminution of volume. Therefore at great depths under high pressure these are the first minerals to be formed. But after extrusion, under ordinary pressure, it is fusibility only which governs, and then it is the feldspars that crystallize first, and afterwards the ferro-magnesian silicates. In the depths of the earth the order of consolidation of the silicates should therefore be in the order of diminution of the coefficient $V' \div v$ shown in the foregoing table. These considerations relative to the action of pressure on consolidation and volume have been expressed by Brauns in "Chemical Mineralogy," by Neiss, Sorby, etc.

As to other factors that influence the order of consolidation of minerals, there remain: (1) The affinity of the bases for SiO_2. (2) The effect of specific gravity. (3) The rôle of pressure.

(1) *Affinity of the Bases for* SiO_2.

When two bases are placed in the presence of an acid, the division of the acid between them is not equal, but in proportion to the affinity between the bases and the acid. If the base has a strong affinity for the acid, it often forms acid salts (if the acid is polybasic), such as KOH, H_2SO_4 and $KHSO_4$. Potassium has more affinity for SiO_2 than the other metals, and therefore tends to form salts which are as acid as possible. The author allows that SiO_2 is divided between the bases already in the liquid magma; and that potassium takes possession of SiO_2 in greater proportion, leaving the other metals to share in the remainder. Its action is counterbalanced by the affinity of MgO for SiO_2 which is also very great. In this respect the metals succeed each other in the following order: Potassium, magnesium, sodium, calcium. These ideas have been developed by Lemberg in "Ueber Silicatumwandlungen."

(2) *The effect of specific gravity.*

The liquid magma differentiates according to specific gravity. The heavier parts, which are basic, fall to the bottom; the lighter (Na_2O, SiO_2, etc.) float. Further, the first crystals formed float or fall according to their specific gravity; for example, in the magma of Vesuvius augite falls to the bottom and leucite floats and remains in the superficial parts of the lava. Spherulihs are less heavy than the rock. That is why they are found upon the borders forming randliche Ausbildungsform (Fuchs). Hence the specific gravity influences the differentiation of the magma. According to the researches of F. Küster, in a fused mixture of isomorphous bodies the heaviest are amongst the first to be deposited. The author supposes this rule is applicable to magmas.

(3) *The rôle of pressure.*

It consists in the following:

(a) Pressure can raise or lower the temperature of fusion.

(b) It retains in the magma the mineralizing agents, steam, etc.

(c) It prevents the dissociation of combinations which decompose at a high temperature.

(d) It facilitates or retards the liquation of magmas that are immiscible.

(e) It can separate a part of a magma by compression.

(f) It may have some influence on the structure of the minerals formed.

(a) The first point has been treated.

(b) From this point of view submarine crystallization is very interesting. De Stefani has shown that the pressure of the water of the ocean does not avail to retain in lava the mineralizing agents, that is, the gases; and as lava cools quicker in water, there ought to result glasses and porous lavas, as confirmed by observation. The author thinks that when once the exterior amorphous crust has been formed the magma is protected by this crust, cools slowly and crystallizes. He thinks that the diabases are formed in this manner. These rocks are later denuded, and the primitive crust is rarely encountered. Yet Rosenbusch affirms that diabases are met with "mit geflossener Oberfläsche."

(c) Le Chatelier has shown that $CaCO_3$ does not dissociate at a temperature of 1,000° centigrade. If it be subjected to a pressure of 1,000 kgr. per square centimetre it fuses and on cooling gives a crystalline marble. Therefore when the liquid magma with $CaCO_3$ is under high pressure, there is no dissociation; there may result calcite, marble, cancrinite. But if suddenly the magma communicates with the surface of the earth's crust through a fissure, the pressure diminishes, the magma differentiates. The presence of water in the glass of volcanoes can thus be explained by pressure. Lewinson-Lessing fused pyroxenes, amphiboles and feldspars in an atmosphere of the vapor of water. The fused magma absorbed one per cent. of the water.

Certain minerals cannot be fused without decomposition. If gaseous products are formed during decomposition, this will be stopped by pressure. The author fused hornblende; one of the products of the decomposition was olivine. There are also gaseous products. Thus the author supposes that olivine forms at the expense of the hornblende, but there was none of it when the decomposition of the hornblende was prevented by pressure.

(d) Beckström states that liquation of liquids is a function not only of temperature but also of pressure. Pressure retards or prevents liquation when the latter is accompanied by increase of volume. In the depths of the earth liquation takes place slowly, and depends simply upon the temperature; when the pressure is lessened liquation takes place more rapidly. If the laws of the liquation of mixtures are applicable to magmas we shall be able to explain by it the phenomena of "composite dikes", etc., but these phenomena are but little studied. The author supposes that liquation explains the formation of the large crystals of feldspar, in the andesytes, filled with inclusions of glass. The liquid, or rather the viscous, magma already feldspathized is mixed with another magma. When, for example, pressure diminishes rapidly, the feldspar, which has been a longtime viscous, crystallizes rapidly, and imprisons within itself the other magma forming drops in the crystal. For units of surface of the crystal there should be, according to the author, an equal number of inclusions, if this reasoning is correct.

(e) By pressure the magma can penetrate into fissures. If it penetrates prior to crystallization, the dike-rocks differ from massive rocks only in structure. If on the contrary the filling of the fissures takes place after crystallization of the magma, we have veins constituted of a different magma, an extract from the primordial magma, rising under the effect of pressure. Then the vein-rocks differ from the massive as to chemical composition, for example greisen and granite (Harker).

(f) When the crystals form when they are yet soft they can be bent, under pressure, which Weinshenk calls piez-crystallization. We would have then, by the action of pressure, often even quite slight, original curved crystals without recourse to the theory of dynamic action. At the moment of their formation a feeble pressure, such, for example, as the surrounding mass exerts at the moment of consolidation, is sufficient to bend a crystal. The author obtained one bent crystal of augite during his experiments on the fusion of pyroxenes and hornblendes in a Fourquignon oven. Hence he distrusts dynamo-metamorphic action.

Magmatic Differentiation.

Volcanic inclusions have very great significance for differentiation, a significance which has been rather misunderstood until quite lately. The author cites, in favor of the rôle which they play in differentiation, the following arguments:

I. A priori ideas. It is difficult to suppose that a great mass of a liquid magma can be in contact with the walls of the reservoir without partially fusing them. By removing blocks, and by fusion, the passages to the surface are increased in size. It is known that Michel Lévy, Suess and others allow that, in the case of granites, limestones have been fused and assimilated; and that Brögger objects, and asks for the proof, since the granites, at least of Christiania, contain only one-half of one per cent of lime. But, according to Lewinson-Lessing, it is the non-differentiated fundamental magma which assimilates the limestones, and then, only, occurs the division of the magma into two, viz: the granite portion poor in lime and the magma of the gabbros which are rich in lime.

II. The gaseous products of eruptions, especially steam and carbonic acid. The latter may come from assimilated limestones, and the former from shales.

III. Inclusions. These are so frequent and they are so much corroded that they testify to the great importance of assimilated masses. The student may examine the work of Lacroix: "Enclaves des roches volcaniques."

IV. The contacting surfaces of dikes. In the case of certain dikes, not very numerous, however, the contacts present evidences of fusion, and the dike contains inclusions derived from the wall. Lewinson-Lessing has observed such at Caucasus, in the granites of Darial, and in dikes of diabase. Harker, in "The Carrock Fell," cites such inclusions in the gabbros and granophyres.

V. Minerals accompanying contacts. These have been fully set forth by Lacroix (Enclaves des Roches, etc.) and by others.

This theory of assimilation is called "osmotic," by Johnston-Lévis because it appeals to osmose to explain the interchange of materials that goes on between the magma and the inclusions. The author does not hold that view. When resorption takes place on a small scale, there is a production of contact minerals. When the magma resorbs great mineral masses there is differentiation; for instance, the resorption of limestones or dolomytes by an acid magma transforms the latter into a neutral magma, but, after a certain limit there occurs a separation into two magmas, an acid with alkalies and a basic with alkaline earths. The principal phenomenon of differentiation is the division into two magmas:—feldspathic and ferromagnesian, but this phenomenon is the product of liquation and not by osmose. Liquation can be instigated by different causes: by inclusions, by variation of pressure, etc.

It might be thought that the resorption of great rock masses, requiring heat, could not take place on a grand scale. But in the greater number of cases the magma becomes more fusible after resorption; for instance, the magnesian magma becomes more fusible after the resorption of lime, and consequently capable of new assimilations. And, further the temperature of fusion of a mixed body is less than temperature of the constituent bodies. For differentiation it is also necessary to consider the rôle which the different oxides can play. Vogt says that the magma becomes more fusible when it becomes rich in FeO, MgO or MnO. On the contrary K_2O and Al_2O_3

render it viscous and difficultly fusible. According to Vogt a certain percentage of Al_2O_3 in the magma obstructs crystallization. Lewison-Lessing says that the peridotic magma with seven to ten per cent. of Al_2O_3 crystallizes with a great quantity of glass, while magmas without alumina have no glass on consolidation.

Resumé. Differentiation takes place, according to Lewinson-Lessing, in the following manner: The igneous magma mixes with a second magma, or assimilates rocks which it encounters in its passage. In this way it becomes rich or saturated with one or more component parts. The higher the temperature the greater the liquidity and the more abnormal the composition may become. Distinct differentiation then takes place only by the lowering of the temperature. When the temperature approaches that of solidification as the magma becomes viscous, chemical affinity begins to play a dominant rôle. In this magma the bases share the SiO_2 between them, according to their respective affinities. At this moment the minerals are already formed in the state of silicates which will crystallize or will form in glass, on eruption, according to the conditions of crystallization. This last moment before solidification appears so important to the author that he proposes to distinguish three kinds of differentiation, viz: (1) Magmatic differentiation, or static, taking place in the depths of the earth (dans la profondeur). (2) Differentiation by cooling, during the ascent to the surface (a little before solidification). (3) Crystalline differentiation.

In the first the principal factors are, specific gravity, temperature, pressure; while the second takes place as liquation under the influence of assimilated inclusions, and during the third phase the principal rôle is played by the chemical affinities.

Lewinson-Lessing rejects in a few lines, the principle of Soret as applied to magmas, and presents some considerations upon the application of the rule of Gibbs of phases in the phenomena of differentiation, reaching the conclusion that the minerals formed cannot be heterogeneous and indefinite but that they are determined a priori; and rests on the "Grengehalt" in saturated solutions, etc. These considerations, occupying several pages, are rather superficially treated, and are omitted here.

As to the specially descriptive part of the work, that is sufficiently presented in the French resumé added to the book along with the general conclusions. In this part are rock descriptions which are not of much interest. He offers also some considerations on dynamo-metamorphism, but nothing new. These are given simply for the purpose of explaining what is his point of view. Having first been an adept disciple and servant of Rosenbusch he has later changed his mind.

Concluding Remarks by the reviewer.

The reviewer does not at all judge of the descriptive portion of this work, not being acquainted with the petrography of the Caucasus. He simply remarks that of 404 pages 150 are occupied with the descriptive portion. The theoretical portion greatly preponderates. Of this part Chapters III and IV are not resuméd.

In chapter II, on differentiation, there seems not to be any new ideas, as Lacroix has already said for the portion concerning magmatic differentiation.

As to chapter I on classification—here the idea of the coefficient of acidity (α) was applied before the author by Schröckenstein; the discussion of the relations between the oxides, $R_2O:RO$, and $Na_2O:K_2O$, has been presented before by Lang, Iddings, etc.; the considerations on the oxides in function of the content of SiO_2 were introduced by Rosenbusch and others (Lapparent, Geologie, p. 600); the curves of tables I-III were constructed according to the curves published by Iddings; Lewinson-Lessing says (p. 242) that the work of Iddings in which are found these diagrams and conclusions similar to his own ("Origin of Igneous rocks"), was unknown to him, for, in spite of all his efforts, he was only able to obtain the book when his own was already in process of publication. Now, it is to be noted that the book of Lewinson-Lessing, according to his statement in the preface, was printed at the commencement of the year 1897, and that of Iddings in 1892. Further, the author cites this same book often, and even antagonizes Iddings. And then, a professor at a university not being able, in spite of all his efforts, to obtain a book in five years! This may be taken as an index of the value of this work.

In fine, the work is a compilation, and an arrangement, more or less ingenious, of the ideas of others. Its individual merit consists in having 345 little calculations for the table of classification, and several other computations the results of which are expressed in the table giving the value of v, v', V and $V \div v$.

ENGLACIAL DRIFT IN THE MISSISSIPPI BASIN.

BY WARREN UPHAM, St. Paul, Minn.

The hilly and mountainous eastern quarter of our continent, comprising the Appalachian mountain belt and the plateau and northern mountains of Labrador, has nearly everywhere so prominent inequality of contour that the ice-sheet in its slow movement outward from its central areas of deepest accumulation may well be supposed to have gathered much drift into its lower part by erosion from the ridges and peaks which it enveloped, so that it would contain englacial drift up to altitudes far above the valleys and lowlands. In the same way the part of the ice-sheet lying on the yet more ruggedly mountainous Cordilleran belt must have borne along in its mass the eroded drift of the mountain sides and of all hill ranges which it covered. We are not surprised, therefore, to find in the drift formations of these partly hilly and partly mountainous regions abundant evidence that a great amount of drift was englacial at the time of the final melting of the ice-sheet.

On the other hand, the broad central belt from Hudson bay and the Arctic sea southward through Manitoba and along all the axial region of the Mississippi basin has a prevailingly flat and only rarely and scantily hilly or mountainous surface, so that in that part of the drift-bearing area one might expect little or no drift to exist in the ice-sheet at any considerable hight above its base. This supposition, however, would be mistaken, for in central Manitoba, at the esker called Bird's hill, seven miles northeast of Winnipeg, my observations in 1887 demonstrated that much drift was borne there in the ice moving over that flat country with no prominent mountains or hills in all the region of its accumulation and outflow whence the ice-inclosed drift could be derived without being

carried upward by glacial currents from lowlands. During the twelve years since my examination of Bird's hill I have often thought over its evidence, which seems to me incontrovertible, that much drift existed there within the ice-sheet at greater altitudes than 500 feet above the very level country on which it rested, and from which the drift had been eroded and borne upward into the ice.*

No other locality known to me is so clear and certain in its testimony of abundant englacial drift transportation upon plain regions; although the high and solitary kame named Devil's Heart hill, in North Dakota,† would apparently surpass Bird's hill in this evidence, except for the very significant relation of the latter to the highest stage of the glacial lake Agassiz. It may be added also that to my mind almost equally convincing proof of much englacial drift in the same region is supplied by its conspicuous marginal moraines, which attain altitudes of 200 to 350 feet in the Leaf hills of western central Minnesota, and half as great altitudes on their best developed tracts in North Dakota.

Proceeding southward to the upper part of the Mississippi basin, we have near New Ulm and Rush City, respectively in southern and eastern Minnesota, sheets of till at the surface, 15 to 20 feet thick, which I think to have been englacial and deposited from the ice when it melted, lying on thick and extensive beds of modified drift.‡

The Rush City plain, occupying the northeast part of Chisago county, Minnesota, drained by the St. Croix river to the Mississippi, is especially instructive. The surface of this tract is yellow till, 10 to 20 feet deep, brought by an ice current from the northwest. Under this till, on an area measuring five miles or more in both length and width, is a greater but undetermined thickness of red sand and gravel, supplied from the melting of ice which had earlier flowed thus far from the region of lake Superior on the northeast. Unlike derivation of these drift deposits is known by their material. The early

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*Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, vol. iv, for 1888-89 Part E, pp. 38-42, with a section. U. S. Geol. Survey, Monograph xxv, 1896, pp. 183-188, with map and section.

†Bulletin, G. S. A., vol. v, 1894, pp. 76-79. U. S. Geol. Survey, Mon. xxv, p. 157.

‡Geol. and Nat. Hist. Survey of Minnesota, Final Report, vol. i, 1884, pp. 581, 582; vol. ii, 1888, pp. 413-417.

red sand and gravel owe their color to red sandstones, shales and conglomerates, of the Keweenawan series in northern Wisconsin and northeastern Minnesota, whence the ice-sheet flowed southwesterly over a large part of eastern Minnesota, continuing southward on the west side of the Wisconsin driftless area. That early glaciation doubtless was confluent with another glacial outflow from the region of lake Winnipeg and Reindeer lake, carrying boulders of limestone from Manitoba southward over the Dakotas and the greater part of Minnesota. South of the driftless area the severed parts of the ice-sheet reunited, and its utmost limit crossed southern Ohio, Indiana and Illinois, central Missouri, northeastern Kansas, eastern Nebraska and the country adjoining the southwest side of the Missouri river in the Dakotas and Montana. From the maximum extension thus outlined, the ice-sheet had been melted back about four hundred miles, but only about seventy-five miles from the nearest northern part of the driftless area, when the red modified drift at Rush City was deposited. How long that tract remained a land surface we cannot reliably determine; but not improbably it was so during the long interval between the Kansan and Iowan stages of glaciation. Five miles west of Rush City, wood and peaty matter occur in a layer of clay at the top of the modified drift, covered by 8 or 10 feet of the later northwestern till, showing that after a stage of recession the ice-sheet again extended over this sand and gravel plain, this time flowing here in a direction nearly at right angles with its former course. Contemporaneously, however, at no great distance eastward, there was quite surely a confluent glaciation from the northeast. Upon a belt reaching from St. Paul and Minneapolis northward across Minnesota the northeastern and northwestern glacial currents met and contended, now one and now the other pushing back its opponent, during all the successive stages of the Glacial period.

Let us next consider the thickness of the very uniform sheet of superficial till at Rush City in comparison with its area. Its linear extension, across the tract where it was ascertained by many wells to be continuously underlain by the early modified drift, exceeds its thickness more than a thousandfold. Its mode of deposition, having been englacial and afterward superglacial drift, may be best indicated by an extract from my report (Minnesota, vol. ii, p. 417), as follows:

The till covering the earlier modified drift and forming the plain at Rush City appears not to have been deposited until the ice in which it had been held was melted away. This ice in its onflow did not erode the modified drift, at least in any considerable amount, else its level contour would be destroyed; and at the same time it seems impossible that a sheet of till having so uniform thickness upon so large an area could be formed as a ground-moraine. Obviously the till here was brought to this area and spread upon it while it was contained in the mass of the onflowing ice, and it seems almost equally sure that it remained thus in the ice till this was melted.

In qualification of this explanation, it should be added that I regard the later ice extension, like the earlier, as due more to snowfall on this area than to ice invasion, although all the upper till was brought by the comparatively small proportion of inflowing ice. In other words, the ice-sheet could not advance with a steep border and leave the sand plain so unchanged; but it was attenuated in its first advance, being formed by local snowfall, and was reinforced soon by some inflow from the higher part of the ice-sheet that had remained unmelted, bringing its englacial drift.

So great recession of the ice-sheet, preceding its extension in the Iowan stage of glaciation, is indicated by wood, peat, and fresh water molluscan shells, found in sections of interglacial beds, underlain and overlain by till, at various localities in the southern half of Minnesota, as noted in the first and second volumes of the final report on the geology of this state. Other localities and general drift features of the same region, likewise described in these volumes, show that the Iowan glaciation, continuing through a far shorter time than the earlier and maximum Kansan glaciation, was therefore insufficient to obliterate some of the larger valleys that were channelled by the streams during the long time between these principal stages of glaciation. Thus the deep valley of the Minnesota river appears to have persisted, without becoming generally filled with drift, under the ice-sheet in its Iowan readvance; and the valleys of head streams of the interglacial Des Moines river are preserved and marked in parts of their courses by three somewhat parallel chains of lakes in Martin county, Minnesota, adjoining the north line of Iowa. Subglacial transportation of the Iowan drift would have caused it to fill and thus bridge the transverse Minnesota valley; but its englacial transportation would favor the preservation of these

valleys, because the moderate volume of this drift, somewhat evenly spread in falling to the ground when the ice melted, was inadequate to fill them.

From such observations and consideration of our Minnesota drift deposits, it becomes evident to my mind that the till of the Iowan glacial readvance is mainly a formation supplied from englacial and finally superglacial drift falling on all the area of that glaciation when the ice in which it had been held disappeared. More than twenty-five years ago, Prof. N. H Winchell clearly stated his belief in the englacial transportation of the drift and its exposure on the surface of the waning ice-sheet.* His very picturesque description of these conditions, as applied to the Glacial period, has since been, in a sense, verified by the discovery of the waning Malaspina ice-sheet of Alaska, covered on its border with drift and a growing forest to the width of a few miles and above hundreds of feet of ice. Somewhat earlier, Prof. James D. Dana had published similar views of the manner in which the ice-sheet worked. During my early studies of the glacial and modified drift in New Hampshire, southern New England, and Long Island, and afterward in Minnesota, where during twenty years I have studied its drift deposits, all my observations and conclusions fall into agreement with these views of Dana and Winchell. Therefore it is with a full measure of confidence that the same belief in englacial and later superglacial origin of the Iowan till is here extended to its development on its type area of eastern Iowa, although this explanation is unlike the opinions of Chamberlin,† who first defined and named this glacial stage and its deposits, and equally discordant with the inferences of Calvin in his recent very able paper on this subject.‡

As Crosby has well remarked, the englacial drift probably became in most regions partly banked beneath the borders of the ice-sheet during its departure, forming then a ground-moraine, while another and larger part remained in and on the ice and fell at last as the upper and looser part of the till.§ In

*Popular Science Monthly, vol. iii, pp. 293, 294, July, 1873.

†Chapter xlii, in Prof. James Geikie's Great Ice Age, third edition, 1894.

‡Bulletin, G. S. A., vol. x, pp. 107-120, March 7, 1899.

§Am. Geologist, vol. xvii, pp. 203-234, April, 1896.

the vicinity of Rush City, Minn., however, and on most of the area of the Iowan till in eastern Iowa, the somewhat uniform but remarkably thin development of this upper deposit of till seems to me consistent only with its having remained chiefly englacial until it was laid bare on the ice by ablation. Being thus exposed, as it could not be in a subglacial position, to the waters of the glacial melting and of rains, it yielded the very large volume of the loess washed from it and deposited just outside the boundaries of the Iowan glaciation. Indeed, in the case of the paha plateaus and ridges, which McGee has very fully described, loess occurs within the glaciated area on tracts that projected in depressions of the thin ice-sheet, and along the courses of streams that flowed in channels walled on each side with ice, being also at their beginning in some instances underlain by ice. The loess seems to me to prove for the Iowan glaciation, like the coarser modified drift of New England and Minnesota, that the margin of the departing ice-sheet at last became covered by its previously englacial drift, whence so vast deposits of gravel, sand, clay and loess were readily washed away to be laid down mostly near the receding ice boundary.

Similarly I believe, also, that the older Illinoian and Kansan till sheets include as their upper portion a large amount of drift that was finally superglacial. This part of the early drift comprises much preglacially decayed rock material eroded from the Tertiary land surface; and hence decaying and disintegrating boulders and pebbles are usually frequent or abundant in it, while its finer drift is prevailingly leached like the preglacial residuary clays from which it was largely derived. Occasionally, however, as Bain has described the old till, probably Kansan, of western Iowa,* it has in some localities an unleached condition even at its surface, which may have been due to peculiar marginal glacial currents, during the departure of the ice, carrying lower parts of the englacial drift upward in these places and removing the normal upper till, so that undecayed boulders and calcareous drift are there anomalously predominant.

*Am. Geologist, vol. xxiii, pp. 168-176, March, 1899.

THE HATTERAS AXIS IN TRIASSIC AND IN MIOCENE TIME.

By L. C. Glenn, Baltimore, Md.

In a recently made study of the Triassic of eastern North America certain lithological, structural, and dynamical facts were found so grouped as to point to the existence of the southern Virginia-North Carolina Triassic region as an area of maximum stability, or of minimum movement, during Triassic time. Also investigations now in progress by the writer on the paleontology of the Miocene of the Carolina region, show that it was a land area during early and perhaps middle Miocene time and was then submerged by a marked transgression of the sea westward across this land area when later Miocene deposits were laid down upon it.

So far as is known these facts have not heretofore been recognized. They are deemed of enough physiographic importance to warrant a brief statement. With them will be briefly noted the evidence bearing on the same problem furnished by the other coastal plain formations of the region. The treatment will follow the order of the succession of the formations involved.

In the Triassic of the Connecticut valley region, as is shown by Prof. Davis,* there is strong evidence in the cross-bedding, ripple marking and coarseness of the deposits and in the mud cracks, rain drops and footprints found through such a great vertical thickness of the deposits, to show that during the time of Triassic deposition in that region deformation was in active progress, and subsidence was constantly going on. These deposits, mainly coarse and all quite near the land from which they were derived, must have been laid down comparatively rapidly; and while the basin was ever almost filled, yet the subsidence was so rapid it was never quite full.

The same conclusion as to deformation and subsidence is reached by another line of evidence. While in the Connecticut Triassic impressions of large strap-shaped leaves, pieces of tree trunks and even some carbonaceous shale are found, yet deposits of coal are wanting, showing that at no time did subsidence cease long enough or progress slowly enough to

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*18th Ann. Rept. U. S. Geol. Sur., Pt. II, p. 34 and ffg.

permit the development of coal swamps and the accumulation of enough carbonaceous material to form coal deposits.

Again, the extensive extrusive lava sheets poured out while the series was forming and the intrusive sheets that were in place before the occurrence of the great faulting and dyking that marked the close of the period, together with the magnitude of the faulting itself, all point to a deformation rapid enough to prevent the accumulation of coal deposits and strong enough to so greatly weaken the underlying crust as to produce widespread cracking through which extensive extrusive and intrusive lava flows welled up from the interior.

Similar conditions are found in the Nova Scotia area and in the area from New York and New Jersey southward to northern Virginia, except that in the southern extremity of the trough the eruptive activity during Triassic time becomes less marked and the lava sheets become thin and local, or, in places, are wanting.

In contrast to these conditions the southern-Virginia-North Carolina region is characterized by the presence of numerous coal seams reaching four, six, eight, ten, thirteen, and even locally twenty-six feet in thickness*, and also marked by the absence of intrusive and extrusive lava sheets. That is to say, subsidence in this region instead of being comparatively rapid and continuous, as in the more northern areas, must have been not only slow but interrupted now and again by intervals of quiescence during which the relation of coal swamp and lagoon levels remained constant long enough to permit the accumulation of the great thicknesses of carbonaceous material represented in the coal seams found there to-day.

The absence of lava sheets may be viewed as indicating that the crustal depression that developed the Triassic trough was so slow as to permit a readjustment of the displaced matter by sub-crustal lateral flow instead of by extrusion to the surface,—a method of readjustment that was aided, perhaps, by the crustal portion yielding so slowly as to escape being as greatly weakened and cracked as was the portion farther north, and so offering during the development of the trough greater

*Russell, I. C. Correlation Papers, The Newark System, Bull. No. 85, U. S. Geol. Sur. pp. 36-42.

resistance to extrusive flows than did the more strongly deformed crust of this northern region. In other words, it would seem that this southern-Virginia-North Carolina region as compared with the more northern Triassic areas yielded less during Triassic time to deformation, or was a region of comparative stability.

While a close study of the structure of this southern portion of the Triassic has never been made, yet the facts at hand indicate that the magnitude of the faulting here was probably not so great as in the more northern areas. This faulting with its accompanying dyking presumably marked the close of the Triassic and would indicate that at that time, also, this southern-Virginia-North Carolina region was a region of comparative stability.

McGee speaks of the Potomac thinning in passing from Virginia into North Carolina, being but a few feet thick at Weldon and in the vicinity of Wilson being absent, probably because of removal through degradation.* Some distance southward of this point, along the line between North and South Carolina, the writer has seen it well developed. There would seem to be a thinning of the Potomac then across a part of central North Carolina because either of non-deposition or of subsequent erosion.

The upper, marine Cretaceous has a thickness of at least five hundred feet in the southern portion of the North Carolina coastal plain, as is shown by a boring in it at Wilmington. During upper Cretaceous time, then, there must have been considerable subsidence in this region, but data are not at hand to determine whether it was as great as the subsidence to the north and to the south or not.

Here and in the adjacent part of South Carolina the marine Cretaceous is often exposed at the surface in stream cuttings, and in the slight depressions in its eroded surface are found here and there isolated patches of Eocene or of Miocene deposits a few feet in thickness. During the earlier part of Eocene time, therefore, the region must have remained above sea-level so long, while the Cretaceous peneplaned surface on which the Eocene patches rest was being developed, that when it subsided it either received but a thin deposit of Eocene or

*Amer. Jour. Sci., 3d Ser. vol. 40, p. 20, 1890.

was elevated in time to permit the almost complete erosion of whatever Eocene once existed there.

The evidence as to the conditions in the region during the Miocene is more explicit. Basal and early Miocene deposits with their characteristic fauna are well known to occur as surface formations from New Jersey southward to Richmond and Petersburg, but disappear farther southward. They are reached in the borings at Fort Monroe, where their base rests about 580 feet below the surface. Across the portion of North Carolina under discussion and in the adjacent portion of South Carolina the few feet of Miocene that are found bear not an early but a late Miocene fauna, and where the writer has seen them are of rather coarse texture, consisting of sands rather than of clays. The evidence then leads to the conclusion that this Carolina region was a land area in early Miocene time, while north of it there existed a great Miocene embayment extending westward as far as Richmond and northward through New Jersey, in which the diatomaceous and other older Miocene deposits of that region were being laid down several hundred feet thick.

During this early and perhaps middle Miocene time the Cretaceous and Eocene land surface of this region must have been well reduced and a mid-Miocene peneplain well developed, on which the late Miocene deposits rest. These late Miocene deposits tell of a subsidence of the land and a marked westward transgression of the sea across it as a necesssary antecedent condition of their formation. The thinness of these deposits together with their lithological and faunal characteristics indicate that the submergence was not very great and was perhaps not of very long duration.

During the several oscillations of the coastal plain since the beginning of Lafayette time there has been, as McGee has shown*, minimum movement in the region of the Hatteras axis, and he describes it as "an axis of interruption or change in epeirogenic movement during every geologic period since the Cretaceous."†

By the term axis, the present writer—as doubtless, also,

*The Lafayettee Formation, 12th Ann. Rept., U. S. Geol. Sur., pp. 486, 514, etc., 1891.

†Ibid, p. 403.

others that have written on the subject—means not a narrow belt with a close approach to the idea of a line but rather a broader belt or a region. Nor is it conceived, with the existence of such a region of stability granted, that its extent was always even approximately the same, or that the position across this stable area of its line of minimum movement was always the same. As compared with this region the portions of the coastal plain to the north and to the south are regions of major or maximum movement, and as compared with each other the amount of the movements in these latter regions has certainly at times been unequal. It is conceived, accordingly, that during a period of marked subsidence on both the north and the south, the area of the stable region would most probably be diminished; while during a period of greater movement on the north, for example, than on the south, the position of the line of minimum movement across the stable region would most probably be shifted southward and vice versa.

Attention was first called to the Hatteras axis by Prof. Shaler in 1871, who described* an uplift transverse to the Carolina coast which he believed had produced the Hatteras projection. Hays and Campbell† have shown that the contours of the deformed Cretaceous peneplain in the central southern Appalachian region swell out on either side suggesting strongly the existence of a transverse line of uplift that if prolonged in both directions would connect the Paleozoic Cincinnati region of uplift with the Hatteras region, and making it a pertinent query whether the Hatteras axis may not have also existed in Paleozoic time. Whether this query may ultimately be found capable of answer or not, it seems reasonable to conclude from the contrast of conditions in the Triassic stated above, that the existence of the Hatteras region as one of comparative stability may be carried back a step or two farther than it has heretofore been recognized and may be considered as existing as early at least as Triassic time.

Geological Laboratory, Johns Hopkins University, May, 5, 1899.

*On the Causes which have led to the Production of Cape Hatteras. Proc. Bost. Soc. Nat. Hist., xiv, pp. 101-121.

†Geomorphology of the Southern Appalachians, Nat. Geog. Mag. vi, pp. 63-126, 1894.

OBSERVATIONS ON DIRTSTORMS.

By E. O. HERSHEY, Freeport, Ill.

NOTE.--The following paper was written three years ago. It was communicated to the undersigned, who had intended to publish it elsewhere. Observations on the geological work of the wind are not often recorded and this paper is too valuable to escape publication, even if it has been delayed. It evidences the usual keen observation and penetration of an author whose ability I highly appreciate.

J. A. UDDEN.

The recent "dirtstorm" which spread a thin sheet of wind-carried silt, derived from the dry soil of the great plains over a large part of the state of Illinois and contiguous areas, has aroused general interest in the subject. A few observations on this and several similar storms, which have occurred in parts of the great central basin of our country during the past few years, may not be devoid of value in aiding in the final solution of the problems which these wide-spread distributions of dust present.

Dirtstorms and sandstorms are of frequent occurrence at all seasons of the year on the great plains, and during the summer are by no means uncommon in Illinois. But the conditions are exceptional under which these clouds of dust are carried as far east as lake Michigan in mid-winter, when the greater portion of the Northwest is under a more or less continuous covering of snow. During several years residence in the city of Freeport in the northwestern portion of the state, only two storms of this character have been observed by the writer. The first occurred a little more than a week before the great storm and lasted only a few hours. It was accompanied by a slight fall of snow of the blizzard variety and was brought by a moderately strong wind from a due westerly direction. The dust in the atmosphere presented the appearance of a haze or very thin fog of a light brown color. The color always distinguishes the presence of dust. When the haze is white it consists of water particles; when of a bluish tint, of carbon particles or smoke; and when of a distinctly brownish tint, the constituent particles are invariably an impalpable dust.

The great storm which has attracted so much attention, reached the city of Freeport shortly after noon on February 18, 1896. During the forenoon there had beeen light flurries of snow, but by noon all snow clouds had disappeared from

the horizon. A strong wind began to blow from the west, and shortly after the peculiar brown haze was observed in the atmosphere. This gradually thickened as the afternoon advanced and culminated at 4:30 p. m. At this time objects one mile distant were scarcely visible, and the sun was as completely obscured as though hidden by the ordinary vapor clouds. Yet during the afternoon not a single true cloud passed over this district, as could be readily determined by looking upward, when the blue sky was discernible, though faintly so. An impalpable dust of dark brown color settled on the snow and collected behind wind-breaks on its surface, so as to completely bury it from sight in places. The impression made on the senses of taste and smell was identical with that experienced in an ordinary summer dust storm. The precipitation of dust continued during the night and the dirt haze was visible the next day until evening. During the 30 hours in which the precipitation of dirt continued, no snow fell at Freeport, and the absence of the ordinary aqueous clouds was especially characteristic of this time. On the second day the wind had veered to the northwest, and the amount of dust decreased, being brought in a more roundabout way than the preceding day.

There are several facts which bear strongly on the manner in which this fine soil material was carried in the atmosphere. The stratum of the atmosphere containing the dirt was confined to a close proximity to the earth. The density of the haze was greatest in the lower 500 feet of the air and decreased rapidly upward. The blueness of the sky could nearly always be detected by looking upward, yet objects on the earth one mile distant were barely visible. Several thousand feet was probably the maximum thickness of the dirt-bearing stratum. Again, the variable currents of the air tore the upper portion of the brown haze into isolated masses which passed before the sun like ordinary clouds. This cloud-like form of the dirt masses is characteristic of all these mid-winter storms when at their highest, and seems to indicate the violence of the air currents in which they are carried. To an observer it was impossible to escape the conviction that the dirt was confined to the stormy stratum of air resting on the earth and reaching to no great hight above it. Also that the dust was driven along by the violent circulation of the atmosphere and reached the earth

chiefly by impact and a fixing of the dirt particles by the uneven surface of the snow and other obstructions.

During last spring the writer, while on the Ozark plateau in southern Missouri, experienced several similar storms of fine dust. One equal in prominence to the recent one in the Northwest, followed a severe blizzard. One morning the snow was found to be discolored by an impalpable dust of a dark brown color, and the atmosphere was still so heavily laden with dust that objects one-half mile distant were invisible. During this storm the cold was intense for that latitude, there was no fall of snow and the atmosphere perfectly free from clouds except the peculiar brown dirt-clouds. If the wind maintained the same direction from the area in which it gathered up the dust, which it had when observed, the origin of the material may be referred to central Kansas.

In the early part of April a heavy southwest wind brought a similar duststorm into the district. It was terminated by rain, which apparently precipitated it, completely clearly the atmosphere near the earth. After the rain, which was of the fine, drizzling variety, the sky remained cloudy for eight hours. The clouds were broken and comparatively high. Among the white aqueous cloud masses there were frequent appearances of similarly shaped clouds of a buff color. The latter were undoubtedly bodies of disseminated dust, which had been carried up into a higher stratum than that next the earth and passed over this district in the same manner as the ordinary clouds. The contrast between the two colors of clouds was strong and gave the sky a checkered appearance which is not very often seen. The direction of the wind pointed to an origin of the material from the prairies of northern Texas and southern Oklahoma.

The bearing of the preceding facts on some of the theories advanced in explanation of the recent "Black Snow" of Chicago and vicinity is obvious. The dust was gathered up from some remote district of the Northwest, carried by the violence of the wind, like sediment in a current of water, across hundreds of miles of snow covered country, and precipitated about Chicago, in conjunction with, but not as the result of, a fall of snow.

Freeport, Illinois, Feb. 20, 1896.

REVIEW OF RECENT GEOLOGICAL LITERATURE.

Researches into the Monograptidæ of the Scanian Rastrites Beds. By S. L. TORNQUIST. (Lunds Universit. Araskrift. Bd. 35, Afdel. 2, No. 1, Lund. 1899.)

Under the above title Prof. Tornquist gives a further account of his studies on the Swedish (Upp.) Silurian Graptolites. The present memoir is confined to the Monograptidæ, the Diplograptidæ and Heteroprionidæ having been treated of in a memoir published in 1897. (Acta Universit. Lund. Tom. XXXIII, Andra afd. Lund, 1897.)

The species of these beds are fully described and Prof. Tornquist says there is, besides, much material too fragmentary for treatment. Quite a number of species are those of Lapworth, Portlack, Barrande and other authors, and ten new species are described. Four plates of admirably executed figures accompany the memoir. G. F. M.

Palæontologiska notiser af Gerhard Holm. (Geol. Fören. i. Stockholm Förhandl. Bd. 20, Hft. 7, 1898.)

11. *Om ett par Bactrites-likands Undersiluriska Orthocer-former.*

The red Lituite limestone of Falköping and Oeland has yielded to Dr. Holm two Orthoceras-like cephalopods which he refers to a new genus, "Bactroceras." He says that they are without doubt of the same generic type as "*Bactrites sandbergeri*" of Barrande found in Bohemia and coming from Dd., or the base of the Lower Silurian. The species which Dr. Holm cites were originally described by Rüdiger from drift blocks found in the surface deposits of Mecklenburg in Germany and placed by him under Endoceras. The new genus is characterized by a thread-like marginal siphon, with long funnel-shaped septal tube, etc. A plate of figures shows graphically the characters of the genus.

12. *Om skalspetsen hos Estonioceras.*

In the glauconitiferous Vaginatum limestone of Oeland Dr. Holm has found some well preserved initial parts of the shell of a species of the genus above named, which he figures and describes. The genus was based by Noebling on *E. lamellosum* His. A plate of figures accompanies the article and gives a very good and clear expression of the characters of the genus.

13. *Om den yttre anatomien hos Eurypterus Fischeri. Idem.* Bd. 21, Hft. 1, 1899.

This is a very full account of the anatomy of the crust of Eurypterus fischeri Eichwald. There is an introductory part giving an account of the work of earlier authors on the anatomy of Eurypterus—Nieszkowski, Hall, Woodward and Laurie. The form of the body and the difference of the species from *E. ramipes* Hall is discussed. The distinctions of sex in the species *E. fischeri* are described and comparisons made with the modern Limulus and *Slimonia acuminata* Salt. A full description is given of the claw-antennæ and of the several pairs of feet attached

to the underside of the body; also a description of the carapax, thorax, etc.

Four plates, showing the different parts of the crust, are given. The illustrations are most artistic and faithful. Two restorations, one of the under and another of the upper surface of a female of *E. fischeri* are drawn and are very creditable to the artist, G. Wennman. G. F. M.

Summary Report of the Geological Survey Department [*of Canada*] *for the Year 1898*. By GEORGE M. DAWSON. Director. 208 pages. Ottawa, 1899. Price 10 cents.

This summary of work done during last year states that sixteen parties were engaged in exploration, one being in British Columbia, two in the Yukon district, two in Alberta, four in Ontario, one in Quebec, two in New Brunswick, three in Nova Scotia, and one in Ungava, on the east coast of Hudson bay. Concise preliminary reports of these field parties are here presented, besides statements of the progress of investigations in chemical analyses, mining statistics, paleontology, zoology, botany, mapping, and publication.

The aggregate value of mineral products in Canada during 1897 exceeded $28,000,000, showing an increase of about 27 percentage above the preceding year. For 1898, it is estimated that complete returns will show a further increase of 25 to 30 per cent. During each year the advance was largely due to the development of placer gold mining in the Klondike region.

Two borings in search of petroleum are being made in the northern part of Alberta, its presence being indicated by extensive outcrops of "tar sands" on the Athabasca river; but petroleum of commercial value has not yet been discovered.

Placer gold is reported as profitably mined, both by ordinary hand work and dredging machinery, on the North Saskatchewan. The gold-bearing section of the river reaches about sixty miles above and an equal distance below Edmonton. During the years 1895 to 1897, its yield has been about $50,000 each year. As the gold on this and other rivers does not occur farther west, adjacent to the base of the Rocky mountains, it appears to have been brought with the northeastern glacial drift, from the Laurentian axis or plateau, or also to be partly derived from the Laramie strata of this region, which were found by Tyrrell to be slightly auriferous. West of Edmonton, the country is generally deeply drift-covered, a part of the boulders being of Laurentian rocks, and others of gray quartzites from the Rocky mountains, probably indicating, as the reviewer thinks, a confluence of glacial currents there from the northeast, north, and west.

In Ontario, attention has been given to surveys and mapping north of the Seine river, around lake Nipigon, and in the Michipicoten district; in parts of Quebec and New Brunswick the drift formations have been specially studied; and in Nova Scotia mapping has been carried forward on coal-mining and gold-mining areas.

Northeast of Hudson bay, Mr. A. P. Low has examined the coast

and islands from Cape Wolstenholme south to Great Whale river, finding on the Nastapoka islands very rich deposits of magnetite and hæmatite. After wintering there, he was to continue his exploration during the present summer. W. U.

Wells of Northern Indiana. By FRANK LEVERETT. Water-Supply and Irrigation Papers of the U. S. Geological Survey, No. 21. 82 pages, with two maps. Washington, 1899.

During the author's exploration of the glacial drift and its morainal ridges in Indiana, many notes of wells have been obtained for comparative studies of the drift formations, their thicknesses, and the depths to the bed rock. Those notes, with maps showing the contour of the state, the average depth of the drift, courses of the ten or more concentrically looped moraines, the loess, valley drift, and areas of extinct lakes, are published in this paper, which will be found very useful to the people in many practical ways.

Another paper, of similar scope, by the same author, noting records of wells in southern Indiana, is published as No. 26, of 64 pages, in the same series. W. U.

The Fossil Bison of North America. By FREDERIC A. LUCAS. Proceedings of the U. S. National Museum, No. 1172, in Vol. xxi, pages 755-771, with plates lxv-lxxxiv. Washington, 1899.

Seven species of bison are recognized by fossil remains on this continent, all being probably restricted to the Pleistocene period. The one most abundantly represented, as at the Big Bone Lick, Kentucky, is the single now existing species, which has been nearly exterminated, though formerly it had herds of almost countless numbers. W. U.

Remarks on the Heliolithidæ. By G. LINDSTRÖM. (Kongl. Svenska Vetenskaps-Acad. Handl, Band, 32, No. 1. Stockholm, 1899.)

In this memoir it is chiefly the Swedish species of Heliolithidæ which are reviewed; the Coccoseridæ are appended as a closely allied group.

No true knowledge of these corals can be had without transverse and longitudinal sections; as species which outwardly are alike have a quite dissimilar interior structure. Dr. Lindström depends chiefly upon the internal sketetal characters to distinguish the species and genera, such as the size and shape of the septa, the structure of the coenenchyma, and the dissepiments as seen in longitudinal and transverse sections.

A very full account is given of the coenenchyma which in some species is tubular, in others vesicular. Other forms have the coenenchyma bacular, or compact. The calicle of a Heliolithes precedes the appearance of the coenenchyma. The septa are constantly twelve. Heliolithes were propagated from free swimming larvæ, and also by gemmation, which was the more frequent method. Dr. Lindström excludes from this family many genera which by other authors have been included; Calapœcia, Halysites, Heliopora among others. He allows as genera of Heliolitidæ, Heliolites, Plasmopora, Propora,

Diplapora and Lyellia. Heliolitidæ are most common in Upper Silurian strata; certain genera are found in the Lower Silurian; one species is exclusively Devonian.

Besides the species already named by Eichwald, McCoy, Rœmer, etc., there are twenty-five new species described in this memoir.

The memoir is accompanied by twelve beautifully executed plates, with numerous figures, showing by sections and etched surfaces the structure of the several species described; and it is very thorough, and exhaustive of the subject considered. G. F. M.

Des relations des Mers Devoniennes de Bretagne et des Ardennes, par CHAS. BARROIS. (Société géologique du Nord, Annales, T. xxvi, p. 260, 1898.)

Dr. Barrois' extensive knowledge of the Devonian rocks of France enables him to write with much confidence on the physical conditions of that country during the Devonian age. The conclusions in this article are based largely on the palæontology. He says there were three great sedimentary areas, differing altogether in their relief and their bathymetric conditions. These areas differ entirely in proceeding from north to south, but on the contrary present great uniformity of conditions when followed from east to west, and true homozoic provinces may be recognized in proceeding in that direction.

The first province includes the north of Great Britain and Scandinavia; this is the continental region with lacustrine and fluviatile formations. The second extends from the south of England to the north of Germany. The third province of Paleozoic times, corresponds to a littoral zone; this registers the secular variations of the Devonian shores. The third province extends from west to east, from Britain to the Harz; its sediments are thinner than those of the preceding province, they are finer and more pelagic by their lithological character and thin fauna; this province is characterized by its pelagic facies, mud "ooze" with pteropods holding calcareous nodules with ammonoid shells. With similar characters the Devonian extends into Spain and far to the east. The central plateaux of France, Spain, Bohemia, etc., were islands in this Devonian sea.

L'Extension du Silurien Superieur dans le Pas-de-Calais par CHAS. BARROIS. Ibidem. T. xxvii, p. 212, (1898).

In the exploitation of coal beds beneath the Cretaceous formation near Calais an Upper Silurian limestone was struck which contained fossils of the age of the Wenlock. This limestone has heretofore been assigned to the Lower Carboniferous, but the fossils prove it Silurian. The presence of a Silurian limestone here shows a great fault, as existant before the deposition of the chalk, by which the older rocks were brought to the surface in post-Carboniferous times.

Les Goniatites du Ravin de Conlaric (Haute Garonne) par CHAS. BARROIS. Ibid. T. xxvii, p. 260, (1898).

Goniatites of several genera were found in this ravine. From the

fossils found the author concludes that the passage from Devonian to Carboniferous in the region (Pyrenees) was made by pelagic formations. The series of Carboniferous sediments was almost as complete in the western Pyranees as in the basin of the Donetz, and show the same alternation of pelagic and continental conditions, with predominance of the latter in the upper stages. G. F. M.

Steinbruchindustrie und Steinbruchgeologie, von DR. O. HERMANN. 8vo, pp. xvi, 428, 6 plates, 17 figures in the text. Berlin, Gebrüder Borntræger, 1899. 11 M. 50 pf.

This is a thorough treatise by an author who is acquainted not only with European but also with American works bearing on the use of stone for building and all construction. Not only are all rocks described in familiar terms, but the tools for quarrying and the methods of stone-cutting are illustrated. The internal structures of rocks and their mineral components are fully noted. General descriptions of the usual rock-forming minerals precede the discussion of the rocks, and the rocks discussed are grouped in systematic classification. For the practical German workman this book should become a familiar companion. N. H. W.

West Virginia Geological Survey. By I. C. WHITE, State Geologist. Vol. I, pp. 392. Morgantown, W. Va., 1899.

In the letter transmitting this first report of the state survey to the governor, Prof. White states that his work thus far has been directed chiefly to the great resources of West Virginia in petroleum and natural gas, because during recent years millions of dollars have been annually spent within the state in exploitation and development of these products. But it is further stated that the active work of the survey must cease with the publication of this volume and a preliminary geological map of the state, until a further appropriation shall provide for its continuation with accurate topographical and geological mapping. In a state having so much undeveloped mineral wealth, it is certainly for the financial as well as the educational interests of the people that a thorough survey of its mountainous topography and complicated geologic formations shall be carried forward under the direction of the able geologist and successful mining and drilling expert who has begun this work.

The first part of this volume gives, in 26 pages, an account of the inception and plans of the survey, much emphasis being laid on the need of correct and detailed topographical maps. By co-operation with the national geological survey, these maps can be secured, probably, as elsewhere, with a large part of the cost of the field work and publication borne by the United States. In this connection, an address by Prof. Albert A. Wright, of Oberlin College, on the benefits to be derived by the adjoining state of Ohio from such mapping of its area, is presented, with a corroborating statement by Dr. Walcott, the director of the U. S. Geological Survey, who indicates the probable cost of topographic surveying as about $10 per square mile, this being

nearly the cost of work already done in Massachusetts, Connecticut, and New York.

Part II (pages 27-53, and an appendix in pages 379-392) gives lists of elevations, with distances, along all the principal railroads of the state, as furnished by officers of the railroad companies, and along the Monongahela and Kanawha rivers from levelling by United States engineers.

Part III (pages 54-122), contributed by Mr. Richard U. Goode, of the U. S. Geological Survey, discusses the magnetic declination in West Virginia, with a table noting its amount at the county seat of each of the fifty-five counties of the state, and description of meridian monuments which have been placed at these county seats.

The fourth and final part (in pages 123-378), occupying two-thirds of the volume, is by the state geologist, giving first a historical sketch of the discovery and development of petroleum and natural gas in West Virginia; and, second, detailed consideration of their geology, with description of the rock strata, from near the top of the Permo-Carboniferous series down to the Corniferous limestone, near the base of the Devonian, which have been penetrated in drilling. Many records of the sections of individual oil wells are also presented.

Statistics of the petroleum production of West Virginia range from about 90,000 to 180,000 barrels yearly from 1876 to 1888; and they give an aggregate during the forty years from 1859 to 1898, inclusive, of 73,892,554 barrels. This is only about an eighth as much as Pennsylvania has produced during the same time; but the annual yield of West Virginia is now rapidly approaching equality with Pennsylvania, their respective amounts in the year 1898 being 13,603,135 and 15,232,702 barrels.

Of the wealth of the State in natural gas, Prof. White writes: "Along with this wonderful recent growth of the petroleum industry in West Virginia there has been a corresponding increase in the production of natural gas, so that this State now stands first of all the States of the Union in the production of this matchless fuel, and with proper care in husbanding this source of power and the prevention of needless waste it should last for another generation at least. Nearly all the principal towns of the State west of the Alleghanies are now supplied, or about to be supplied with this fuel, while the Pittsburg region receives many million feet daily through the great 16-inch line of the Philadelphia Company. . . . . The hundreds of drilling wells, and thousands of pumping oil wells, and all of the pipe lines for hauling the oil produced within the State, the water supply, and everything connected with the oil industry, receive practically all their power from the consumption of natural gas, and the quantity thus burned in useful work must run into many millions of cubic feet daily, probably not less than two hundred millions, while the amount wasting into the air from oil wells and safety pressure valves of the pipe lines is probably as much more."

The map of West Virginia, issued with this volume, was compiled

by Russell L. Morris, under the direction of the state geologist. Its scale is ten miles to the inch. It shows nearly half of the state as occupied by coal-bearing strata; while in its northwestern part, within fifty to seventy-five miles southeast, south, and southwest of Wheeling, oil pools and natural gas wells abound. W. U.

The characters of crystals: an introduction to Physical Crystallography. ALFRED J. MOSES. New York, Van Nostrand Company, pp. 211, 1899, net $2.00.

This little work, which is uniform in style with several that have been issued recently by the science members of Columbia University faculty, covers the field of practical mineralogical science, so far as pertains to the necessary apparatus and its use. Thus, most of the topics are treated concisely and without much mathematical investigation. In most cases results and processes are announced, and are assumed to be acceptable to the ordinary student, without the full detail of demonstration. The work is necessarily a compilation of methods and facts familiar to mineralogists, but it has the rare merit of being up to date, embracing several recent newly devised pieces of apparatus. It also has its own style and order of arrangement, and several new figures of illustration. It will prove to be, without question, a very useful book to all who have to do with crystals. It is an important addition to the literature of American mineralogy. N. H. W.

MONTHLY AUTHORS' CATALOGUE
OF AMERICAN GEOLOGICAL LITERATURE, ARRANGED ALPHABETICALLY.*

Bailey, L. W.

Triassic (?) rocks of Digby basin. (Trans. Nova Scotian Inst. of Sci., vol. 9, pt. 4, pp. 356-360, Dec. 31, 1898.)

Bascom, F.

On some dikes in the vicinity of Johns bay, Maine. (Am. Geol., vol. 23, pp. 275-280, pls. 8-11, May, 1899.)

Bell, Robert.

Rising of land around Hudson bay. (Ann. Rept. Smithsonian Inst. for 1897, pp. 359-367, 1898.)

Blue, Archibald.

Corundum in Ontario. (Proc. Canadian Inst., vol. 2, pt. 1, pp. 15-22, Feb. 1899.)

*This list includes titles of articles received up to the 20th of the preceding month, including general geology, physiography, paleontology, petrology and mineralogy.

Broadhead, G. C.

Geology of Boone county, Missouri. (Geol. Survey, Mo., vol. 12, pt. 3, pp. 273-388, 2 pls, 1898.)

Broadhead, G. C.

The Ozark uplift and growth of the Missouri Paleozoic. (Geol. Survey, Mo., vol. 12, pt. 3, pp. 389-409, 1898.)

Clarke, F. W., and Darton, N. H.

On a hydromica from New Jersey. (Am. Jour. Sci., ser. 4, vol. 7, pp. 365-366, May 1899.)

Coleman, A. P.

Lake Iroquois and its predecessor at Toronto. (Bull. Geol. Soc. Am., vol. 10, pp. 165-176, Mch. 24, 1899.)

Crookes, William.

Diamonds. (Ann. Rept. Smithsonian Inst. for 1897, pp. 219-235, 1898.)

Crosby, W. O.

Archean-Cambrian contact near Manitou, Colorado. (Bull. Geol. Soc. Am., vol. 10, pp. 141-164, pls. 14-18, Mch. 23, 1899.)

Darton, N. H. (Clarke, F. W., and)

On a hydromica from New Jersey. (Am. Jour. Sci., ser. 4, vol. 7, pp. 365-366, May 1899.)

Davis, H. J.

Modification in the Jonathan creek drainage basin. (Bull. Sci. Lab. Denison Univ., vol. 11, pp. 165-173, pls. 25-26, Mch. 1899.)

Dawson, G. M.

Summary report of the geological survey department [of Canada] for the year 1898. (208 pp.; Ottawa, 1899.)

Dawson, G. M.

Duplication of geologic formation names. (Science, new ser., vol. 9, pp. 592-593, Apr. 21, 1899.)

Day, D. T.

Mineral resources of the Antilles, Hawaii and the Philippines. (Engineering Mag., vol. 17, pp. 242-251, May 1899.)

Derby, O. A.

On the association of argillaceous rocks with quartz veins in the region of Diamantina, Brazil. (Am. Jour. Sci., ser. 4, vol. 7, pp. 343-356, May 1899.)

Dickhaut, H. E.

Collecting fossils in the Cincinnati shales. (Am. Geol., vol. 23, pp. 335-336, May 1899.)

Diller, J. S.

Description of the Roseburg quadrangle. (U. S. Geol. Survey, Geologic Atlas of the U. S., folio 49, Roseburg folio, Oregon, 1898.)

Diller, J. S.

Origin of Paleotrochis. (Am. Jour. Sci., ser. 4, vol. 7, pp. 337-342, May 1899.)

Diller, J. S.

Latest volcanic eruptions of the Pacific coast. (Science, new ser., vol. 9, pp. 639-640, May 5, 1899.)

Eastman, C. R.

Some new American fossil fishes. (Science, new ser., vol. 9, pp. 642-643, May 5, 1899.)

Ells, R. W.

The mineral resources of the Ottawa district. [Continued.] (Ottawa Naturalist, vol. 13, pp. 25-46, May 1899.)

Ells, R. W.

Progress of geological work in Canada during 1898. (Ottawa Naturalist, vol. 13, pp. 52-55, May 1899.)

Fuller, M. L.

Rapidity of sand-plain growth. (Science, new ser., vol. 9, pp. 643-644, May 5, 1899.)

Faribault, E. R.

The gold measures of Nova Scotia and deep mining. (Read before Can. Min. Inst., March, 1899. Published by Min. Soc. of Nova Scotia. 11 pp., 5 pls.)

Gilbert, G. K.

Glacial sculpture in western New York. (Bull. Geol. Soc. Am., vol. 10, pp. 121-130, Mch. 23, 1899.)

Gilbert, G. K.

Dislocation at Thirtymile point, New York. Bull. Geol. Soc. Am., vol. 10, pp. 131-134, pl. 12, Mch. 23, 1899.)

Gilbert, G. K.

Ripple-marks and cross-bedding. (Bull. Geol. Soc. Am., vol. 10, pp. 135-140, Mch. 23, 1899.)

Goode, R. U.

Variation of the magnetic compass [in West Virginia]. (W. Va. Geol. Survey, vol. 1, pp. 54-122, 1899.)

Grabau, A. W.

Moniloporidæ, a new family of Palæozoic corals. (Proc. Boston Soc. Nat. Hist., vol. 28, no. 16, pp. 409-424, 4 pls., Apr. 1899.)

Gratacap, L. P.

A plea for the popular exposition of lithology for museum purposes. (Am. Geol., vol. 23, pp. 281-287, May 1899.)

Greene, G. K.

Contribution to Indiana palæontology. Pt. III. (Pp. 17-25, pls. 7-9: Ewing and Zeller, New Albany, Ind., Apr. 17, 1899.)

Hay, O. P.

On the names of certain North American fossil vertebrates. (Science, new ser., vol. 9, pp. 593-594, Apr. 21, 1899.)

Herrick, C. L.

Papers on the geology of New Mexico. (Bull. Sci. Lab. Denison Univ., vol. 11, pp. 75-92, pls. 9-12, Dec. 1898.)

Herrick, C. L.

The geology of the San Pedro and the Albuquerque districts. (Bull. Sci. Lab. Denison Univ., vol. 11, pp. 93-116, pl. 13, Dec. 1898.)

Hobbs, W. H.

Goldscmidtite, a new mineral. (Am. Jour. Sci., ser. 4, vol. 7, pp. 357-364, May 1899.)

Irving, J. D.

Some contact phenomena of the Palisade diabase. (School of Mines Quarterly, vol. 20, pp. 213-223, Apr. 1899.)

Kelvin, Lord.

The age of the earth as an abode fitted for life. (Ann. Rept. Smithsonian Inst. for 1897, pp. 337-357, 1898.) (Science, new ser., vol. 9, pp. 665-674, May 12, 1899.)

Keyes, C. R.

The Missourian series of the Carboniferous. (Am. Geol., vol. 23, pp. 298-316, May 1899.)

Marbut, C. F.

Geological description of the Clinton sheet [Missouri]. (Geol. Survey Mo., vol. 12, pt. 2, pp. 17-104, 1 pl., 1 map, 1898.)

Marbut, C. F.

Geological description of the Calhoun sheet [Missouri]. (Geol. Survey Mo., vol. 12, pt. 2, pp. 105-191, 1 pl, 1 map, 1898.)

Marbut, C. F.

Geological description of the Lexington sheet [Missouri]. (Geol. Survey Mo., vol. 12, pt. 2, pp. 193-247, 1 pl., 1 map, 1898.)

Marbut, C. F.

Geology of the Richmond quadrangle [Missouri]. (Geol. Survey Mo., vol. 12, pt. 2, pp. 249-308, 1 pl., 1 map, 1898.)

Marbut, C. F.

Geology of the Huntsville quadrangle [Missouri]. (Geol. Survey Mo., vol. 12, pt. 2, pp. 309-371, 1 map, 1898.)

[Marsh, O. C.]

Othniel Charles Marsh. By J. L. Wortman. (Science, new ser., vol. 9, pp. 561-565, portrait, Apr. 21, 1899.)

[Marsh, O. C.]

Othniel Charles Marsh. (Geol. Mag., new ser., dec. 4, vol. 6, pp. 237-240, [illegible])

Matthew, W. D.

Is the White River Tertiary an æolian formation? (Am. Nat., vol. 33. pp. 403-408, May 1899.)

McGee, W J

"The truth about the Nampa figurine." (Am. Geol., vol. 23, p. 336, May 1899.)

Miller, W. G.

Notes on prospecting for corundum. (Proc. Canadian Inst., vol. 2, pt. 1, pp. 23-26, Feb. 1899.)

Nordenskjold, Otto.

Preliminary notes on the surface geology of the Yukon territory. (Am. Geol., vol. 23, pp. 288-298, May 1899.)

Palache, Charles.

Powellite crystals from Michigan. (Am. Jour. Sci., ser. 4, vol. 7, pp. 367-369, May 1899.)

Shepard, E. M.

A report on Greene county [Missouri]. (Geol. Survey Mo., vol. 12, pt. 1, pp. 13-245, 4 pls., 1 map, 1898.)

Tarr, R. S.

Physical geography of New York state. Pt. vii. The Great Lakes and Niagara. (Bull. Am. Geol. Soc., vol. 31, no. 2, pp. 101-107, 1899.)

Tyrrell, J. B.

Glacial phenomena in the Canadian Yukon district. (Bull. Geol. Soc. Am., vol. 10, pp. 193-198, pl. 21, Apr. 3, 1899.)

Udden, J. A.

The Pine Creek conglomerate [Iowa]. (Reprint from report of Iowa Acad. Sci., 1898; pp. 54-56.)

Udden, J. A.

Diatomaceous earth in Muscatine county [Iowa]. (Reprint from report of Iowa Acad. Sci., 1898; 1 p.)

Upham, Warren.

Modified drift and the Champlain epoch. (Am. Geol., vol. 23, pp. 319-324, May 1899.)

Walker, B. E.

President's address [Paleontology]. (Proc. Canadian Inst., vol. 2, pt. 1, pp. 1-10, Feb. 1899.)

Weeks, F. B.

Duplication of geologic formation names. (Science, new ser., vol. 9, pp. 625-626, Apr. 28, 1899.)

White, I. C.

Annual report of the state geologist [of West Virginia]. (W. Va. Geol. Survey, vol. 1, pp. 7-26, 1899.)

White, I. C.

Levels above tide [in West Virginia]. (W. Va. Geol. Survey, vol. 1. pp. 27-53 and 379-392, 1899.)

White, I. C.
Petroleum and natural gas [in West Virginia]. (W. Va. Geol. Survey, vol. 1, pp. 123-378, 1899.)

White, I. C.
Origin of grahamite. (Bull. Geol. Soc. Am., vol. 10, pp. 277-284, pl. 29, Apr. 25, 1899.)

Wiechmann, F. G.
The optical behavior of quartz under stress. (School of Mines Quarterly, vol. 20, pp. 267-279, Apr. 1899.)

Wieland, G. R.
A study of some American fossil cycads. Part III. The female fructification of Cycadeoidea. (Am. Jour. Sci., ser. 4, vol. 7, pp. 383-391, pls. 8-10, May 1899.)

Williams, H. S.
On the occurrence of Paleotrichis in volcanic rocks in Mexico. (Am. Jour. Sci., ser. 4, vol. 7, pp. 335-336, May 1899.)

Winchell, N. H.
Adularia and other secondary minerals of the copper-bearing rocks. (Am. Geol., vol. 23, pp. 317-318, May 1899.)

Wortman, J. L.
Othniel Charles Marsh. (Science, new ser., vol. 9, pp. 561-565, portrait, Apr. 21, 1899.)

PERSONAL AND SCIENTIFIC NEWS.

PROF. J. S. NEWBERRY at the time of his death left several unfinished manuscripts. Among these was one for a monograph of the United States Geological Survey, entitled "The later extinct floras of North America." It deals with the fossil plants of the Cretaceous and Tertiary of the west. The entire edition of plates was published several years ago, but the descriptive part was in a very incomplete and fragmentary state at the time of Prof. Newberry's death. Dr. Arthur Hollick has taken the manuscript and plates in hand, has hunted out the type specimens and has revised and completed the descriptions. This volume is expected to appear shortly.

ARKANSAS GEOLOGICAL REPORTS. The last legislature of the state of Arkansas provided for the printing of the hitherto uupublished reports of J. C. Branner, formerly state geologist of that state. There are five volumes of these reports, viz: (1) Coal; (2) Lower Coal Measures; (3) Clays,

kaolins and bauxites ; (4) Zinc and lead ; (5) Report on the general geology of the state. Provisions were also made for printing new editions of the reports already out.—(*Science.*)

VICE-PRESIDENT BRANNER, of Stanford University, will conduct an expedition to Brazil during the summer to work upon the geology of the stone and coral reefs of the coast. These reefs, more or less broken, extend from Ceará to the Abrolhos, a distance of more than a thousand miles. Mr. Branner did much work upon these reefs while he was connected with the geological survey of Brazil, but the field observations were never finished and the results of the work were not published. He hopes to complete his work during the summer vacation. The expenses of the expedition will be paid chiefly by Prof. Alexander Agassiz, and the results will be published by the Museum of Comparative Zoology, at Harvard.—(*Science.*)

THE AMERICAN MUSEUM OF NATURAL HISTORY is sending out two expeditions this summer for the collection of vertebrate fossils. One has already gone to continue work in the regions whence so many fine skeletons of Tertiary mammals have come to the Museum, and the other soon goes to get more of the great Mesozoic reptiles.

THE SKELETON OF THE GREAT MOSASAUR which was obtained from the Kansas Cretaceous last season by an American Museum expedition has been mounted and is now on exhibition in the Museum. It has been kept in the matrix and, on account of the double curve in which it lies and the loss of the last ten feet or more of its tail, it occupies a shallow case or frame about thirty feet long by six feet high.

PROF. J. F. KEMP AND MR. G. VAN INGEN will spend the first ten days of June in study field work in geology with Columbia School of Mines students on the Cortlandt series near Peekskill and on the Paleozoic rocks near Rondout. The first ten days of July will be devoted by Prof. Kemp to similar work with another party at and near Iron Mountain, Mo.

DR. ARTHUR HOLLICK plans to spend a week in June studying the strata bordering the Chesapeake bay in company with the Maryland Geological Survey party, preparatory to beginning work on the paleobotany of the state.

WISCONSIN GEOLOGICAL AND NATURAL HISTORY SURVEY. The Wisconsin legislature, which has recently adjourned, has appropriated $10,000 per year, for two years, for this survey, which is under the directorship of Prof. E. A. Birge. The geological work is directed by Prof. C. R. Van Hise, who acts as consulting geologist. The lines of geological investigation to be carried on this summer are as follows: (1) Dr. E. R. Buckley will investigate the clays of the state.

(2) Dr. Samuel Weidman will continue his work on the crystalline rocks of the north-central part of the state. (3) Dr. U. S. Grant, assisted by Dr. C. P. Berkey, is to work on the copper-bearing rocks of Douglas and Bayfield counties. (4) Dr. W. H. Hobbs and C. K. Leith will complete an investigation of the pre-Cambrian volcanics of the Fox River valley. A report on the building stones of the state, by Dr. Buckley, is nearly ready for distribution; and a report by Dr. Weidman, on certain of the pre-Cambrian rocks of the Fox River valley has recently been issued.

PROF. C. H. HITCHCOCK, who has been spending the year in travel, expects to reach home in time for the 51st meeting of the A. A. A. S., at Columbus, and to resume his duties at Dartmouth college upon the opening of the new year. During September last he made a study of certain features of the Hawaiian islands. From there he went to Australia, making as close an examination of the general geology of the continent as time permitted. Later New Zealand was visited, for the purpose of investigating the glaciers and of searching for relics of former greater extension. In February his return trip began, leading across Australia again, and to Honolulu. Since early in March Prof. Hitchcock has been studying in detail the volcanic action and vegetation of the Hawaiian islands.

PROF. N. S. SHALER will continue this season studies which were begun in 1897 and 1898 upon the geology of the gold-bearing slates of Nova Scotia, and the auriferous gravels of portions of Montana.

DR. J. L. WORTMAN has resigned his position of assistant curator of the department of vertebrate paleontology in the American Museum of Natural History, which he has held for about nine years, and has accepted the charge of the department of geology and paleontology in the new Carnegie Museum at Pittsburg, Pa. He is now in the field in Wyoming, beginning the collecting for the new museum.

THE MINNESOTA ACADEMY OF NATURAL SCIENCES has concluded a contract with the Greater American Exposition, at Omaha, for a display of the natural history of the Phillipine islands. The collection will comprise nearly 1000 birds, a large number of vertebrates, including huge bats and snakes, a collection of shells and corals and an elaborate ethnographical display.

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